Africa Research in Sustainable Intensification for the Next Generation
Ethiopian Highlands Project

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The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future (FtF) initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Livestock Research Institute (in the Ethiopian Highlands) and the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa). The International Food Policy Research Institute leads an associated project on monitoring, evaluation, and impact assessment.

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Contents

Summary

Core activities during the reporting period revolved around the implementation of 33 research protocols developed collaboratively with our CGIAR and other partners. These included 22 action protocols with direct involvement from farmers in the eight Africa RISING kebeles and a strong focus on the actions required to implement sustainable intensification strategies. In addition, 11 exploratory protocols are providing us with further insights and evidence around the constraints to and opportunities for SI in the Ethiopian Highlands.

Twelve specific research highlights, mainly covering the field research conducted over the Meher season of 2014, are presented in this document. These relate to:

- Bridging yield gaps through soil test-based nutrient amendments. This research is already showing that responses to fertilizer as part of an intensification strategy can be extremely localized, even varying amongst farms within a kebele;
- Integrating tree lucerne (*Chamaetysisus palmensiss*) in the crop-livestock farming systems. The potential of tree lucerne as a multi-purpose tree legume that is actually adapted to altitude is being explored across the sites;
- Enhancing the productivity of farming systems based on enset. At the Lemo site, enset is a very important multi-purpose crop and this protocol is responding to strong demand for research to improve its resistance to disease and increase productivity over its five year growing period;
- Study on supplemental irrigated fodder production for fattening sheep. This research, conducted in collaboration with ILSSI, has demonstrated the potential of irrigated fodder production to improve farmer access to premium markets for livestock products;
- Integration of high value multipurpose trees with soil and water conservation measures for improved livelihood and reducing land degradation;
- Crop residue utilization and management. Storage losses and inefficient feeding practices are being addressed collaboratively with farmers in this research protocol;
- Learning about adoptability from the technologies that farmers are currently using. This research is taking a historical perspective to learn about some of the key characteristics of “adoptable” technologies and management practices;
- Redesigning Ethiopian cropping systems for improved nutrition, income and food security;
- Improved crop management practices to address yield gaps;
- Facilitating establishment of pilot potato seed businesses and linking them to potato producers. In the Africa RISING diagnostic studies, effective seed supply systems were widely viewed as a pre-requisite for any intensification of crop production systems. This research is exploring opportunities for ensuring local continuity of seed supply;
- Enhancing food security and environmental stability through landscape based integrated water and land management;
- Developing capacities for gender responsiveness in agricultural programs in Ethiopia. Africa RISING in the Ethiopian Highlands has made a strong commitment to mainstreaming gender issues in its research activities. This protocol has supported capacity building amongst all our partners including the identification of local gender champions to support this at site level.

Introduction

The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative[1].

In Ethiopia, the main aim of the project is to identify and validate solutions to the problems experienced by smallholder crop-livestock farmers in the Highlands. Some of these problems arise from the difficulties that farmers face in managing the resources that they have and in capitalising on the efficiencies that managing crops and livestock together can introduce into a farming system. However, realising these potentials is often influenced by other factors such as cost effective access to inputs and the reliability of markets for saleable produce.

To address these complexities, Africa RISING will take an integrated approach to strengthen the farming systems of the Ethiopian highlands. It will conduct research that, from a strong participatory base, identifies technologies and management practices that work for farmers whilst accounting for the wider contexts in which these must operate. These contexts include the nature and effectiveness of markets for inputs and outputs, of community and other institutions and of the policy environments that influence farm households.

What will a successful Africa RISING in Ethiopia look like in 2016? Knowledge and skills in farming communities will have been strengthened equitably, allowing all family members to benefit. We will see farmers operating systems that are 'sustainably intensified'- that is, levels of production and productive efficiency have increased in ways that can be maintained both environmentally and economically over the longer term. Improved partnerships among farmers, support services and other value chain actors will have reduced uncertainties about market function; more reliable input supplies will support more resilient production that will ensure a more consistent profit from produce sold at market.

Africa RISING in Ethiopia is led by scientists from the International Livestock Research Institute in partnership with scientists from other CGIAR centres, the Ethiopian national agricultural research system and local communities.

[1] See http://www.africa-rising.net

Implementation highlights

Identification and implementation of research protocols

In order to implement the Africa RISING rolling work plan, a set of research protocols targeting the main problems and opportunities identified were finalized and are now being implemented during the reporting period. These are summarized in Table 1 under the seven research themes of the work plan and protocol summaries are appended at Annex 1.

Most of the previous activities implemented under the Africa RISING in the Ethiopian Highlands project focused on exploratory diagnostic studies. This has given us a sound base on which to plan our action-based on-farm research which is reflected by the shift in emphasis in the current batch of implemented research protocols. We are currently implementing 22 action related protocols alongside 11 exploratory protocols. However, these latter have changed in emphasis somewhat with the key focus now being on:

- Exploring some more generic issues around sustainable intensification (e.g. research to elucidate indigenous perceptions of sustainability);
- Looking at knowledge management and exchange issues around SI to support the equitable and effective, ground-up scaling activities that we will be implementing from early 2015 (e.g. research on innovations platform communications procedures and the study on gendered constraints to adoption);
- Also in support of our scaling activities, to explore enabling environments for successful adoption (e.g. the historical adoption study).

Table 1. Summary of the research protocols finalized and implemented during the current reporting period.

Africa RISING research thematic areas	**Number of protocols under the thematic areas**	**Research type**
Feed and Forage Development	2	action
Field Crop Varietal Selection and Management	3	action
Integration of High Value Products into Mixed Farming Systems	2	action
Improved Land and Water Management for Sustainability	6	5 action and 1 exploratory
Mixed Farming Systems through more Effective Crop - Livestock Integration	3	2 action and 1 exploratory
Cross Cutting Problems and Opportunities (seed system, VC, market, nutrition, gender)	11	8 action and 3 exploratory
Knowledge Management, Exchange and Capacity Development	6	exploratory
Total	33	22 action and 11 exploratory

Highlights from the Meher Season, 2014 Research

Much of the analysis and interpretation of the research conducted over the most recent Meher Season is ongoing. However we present some initial highlights in the following twelve areas:

- Bridging yield gaps through soil test-based nutrient amendments;
- Integrating tree lucerne (*Chamaetysisus palmensiss*) in the crop-livestock farming systems;
- Enhancing the productivity of farming systems based on enset;
- Study on supplemental irrigated fodder production for fattening sheep;
- Integration of high value multipurpose trees with soil and water conservation measures for improved livelihood and reducing land degradation;
- Crop residue utilization and management;
- Learning about adoptability from the technologies that farmers are currently using;
- Redesigning Ethiopian cropping systems for improved nutrition, income and food security;
- Improved crop management practices to address yield gaps;
- Facilitating establishment of pilot potato seed businesses and linking them to potato producers;
- Enhancing food security and environmental stability through landscape based integrated water and land management;
- Developing capacities for gender responsiveness in agricultural programs in Ethiopia.

Research highlight: Bridging yield gaps through soil test-based nutrient amendments

Supported by donors, Ethiopia has been investing significantly in Sustainable Land Management (SLM), expanding irrigation agriculture, and building small-scale dams and diversions to respond to the environmental calamities they face. The Government of Ethiopia has also been financing the importation of chemical fertilizers, which increased from 200,000 to 550,000 tonnes between the years 1994 and 2010.

However, despite these increasingly large investments, there is no convincing evidence to show an increase in crop and livestock yields per unit of investment. Despite large imports and the application of nitrogen and phosphorus fertilizers in major cereal growing areas of the highlands, there has been limited response of crops to fertilizer application. This could be largely explained by the critical deficiencies of multiple micro and secondary nutrients. The Agricultural Transformation Agency (ATA) has been engaged over the last few years in developing soil maps and blended fertilizer recommendation for the whole country in an attempt to address the nutrient deficiencies that are preventing both rainfed and irrigated agriculture from reaching their full potential.

Capitalizing on ICRISAT's successful approach in the state of Karnataka, India in using soil test-based nutrient management as an entry point to facilitate change and improve livelihoods, the Africa RISING team has been testing the application of various fertilizer blends in 120 farm fields at the four Africa RISING sites using wheat as a test crop. The on-farm experiments have targeted various soil types, landscape positions and rainfall regimes. We have also used these trials for ground-truthing the recommended blended fertilizers as outlined by ATA. Our preliminary results showed three different types of crop responses to fertilizer application, which could be considered as target niches within each kebele.

Group 1. Fertile soils; well-managed farms: In this group, the wheat crop thrived well regardless of type and amount of fertilizer application. Optimum on-farm application of various combinations of fertilizers (Nitrogen, Phosphorus, Potassium, Sulphur, Zinc) did not offer any significant yield advantage over farmers' fields. Hence, our trials were not able to show higher returns that would compensate the cost of applied inputs.

Group 2. Less fertile responsive soils: In this group of farms, there was a significant difference between our treatments and farmers' control fields. The highest yield margin was obtained from the NP application, followed by application of S and K.

Group 3. Less fertile, Non-responsive soils: This are farms where there was no response to any combination or rates of fertilizers. These are commonly degraded lands, with low water holding capacity and limited response to external inputs.

The recommendation of ATA in its fertilizer recommendation map for Tigray is that the highland part of the Endemehoni should receive a blended fertilizer of largely NPKSZnB, while the lowland should receive NPKSZn with a recommended amount of 100 kg blended fertilizer along with 100 kg Urea. As indicated above, our ground-truthing experiments were rarely responding to these types and amounts of inputs in the majority of the farms. However, we expect a yield benefit of up to double yield from application of NPS from Group II type farms. We will keep validating this finding from the other three Africa RISING districts as complete maps for the different regions emerge. Once crop yield, quality and soil and plant analysis have been made, we will share our results to the Ministry of Agriculture and ATA for fine-tuning and adjustments. This will be used to build the capacity of the farmers on what should they apply where in their farms and of the new fertilizer supply initiatives in the country to supply appropriate nutrient combinations to them.

Research highlight: Integrating tree lucerne in the crop-livestock farming systems

Tree Lucerne (*Chamaetysisus palmensiss*) is a nitrogen-fixing, fast growing and ecologically adaptable multipurpose plant species that is being evaluated in the Africa RISING eight research kebeles. Its integration in the crop-livestock farming systems is aimed to contribute to income diversification, improve crop and livestock productivity and enhance the participation of women and children in the research process to benefit them equitably. Eight research groups have already been formed at the four sites. Each research group consists of 20-30 farmers representing a range of social groups.

Growing tree lucerne can have significant service and production benefits for farmers. For instance, most farmers use crop residues and grasses for animal feed. These feed sources have low level of crude protein. Hence, the foliage and pods of tree lucerne can be mixed with the other feed sources to improve nutritional value for animals. Farmers can also sell seed of tree lucerne and diversify their income. Tree lucerne is a plant that can benefit both women and men and potentially addresses the needs of various farm types.

Tree lucerne is one of very few leguminous multipurpose plant species that are adapted to the high altitude areas where Africa RISING is operating. The plant can play a significant role in supporting food security, nutrition and income diversification of smallholder farmers so long as there is technical backstopping on its management and capacity building on integrated agriculture and marketing at all levels (farmers, extension, and research and market actors).

The interest of farmers to grow tree lucerne is increasing in Lemo and other Africa RISING sites although the plant is new to most of the farmers. The number of female headed farmers that participated in the tree lucerne research is 19% in Endamehoni and less than 10% in Lemo (Table 2). This does not mean that womens' participation in this research is insignificant. Married women (woman in a male headed household) are also very active for managing the plants that are grown around homesteads/backyards (Photo 1).

Table 2. Participating farmers in tree lucerne research and performance of the plant in different sites

	Endamehoni (Tigray)	Lemo (SNNPR)
Number of participated households (Male)	44	99
Number of participated households (Female)	10	8
Maximum number of seedlings provided to a farmer	150	866
Minimum number of seedlings provided to a farmer	25	30
Total number of seedlings distributed	6,926	11,260
Where planted	Homestead/backyard, farmland (boundary, SWC structures), irrigated land (boundary), gullies and miscellaneous land.	Homestead/backyard (fence, small plots) and farmland (around terraces)
Average survival (%) two months after planting	63.5 (Tsibet) and 70.7 (Emba Hazti)	85 (Jawe) and 80 (upper Gana)
Major challenges and lessons	Heavy rainfall (flood, hail and water-logging), low levels of farmers' awareness, shortage of land, free grazing system, nursery site distance.	Newness of the plant in the area, high palatability of the young plants by wild and domestic animals, planting space not maintained by some farmers

Photo 1. A married woman (woman in male headed household) managing tree lucerne seedlings planted around the homestead in Jawe Africa RISING research kebele, Lemo site

Research highlight: Enhancing the productivity of farming systems based on enset

Enset is source of food, cash, feed, medicine, sources of fuel wood and other products and services for smallholder farmers. Currently, the productivity and area coverage of the crop is declining due to various biotic and abiotic factors. Diseases such as bacterial wilt (X*anthomonas campestris pv. Musacearum; EXW*), pests (Enset root mealy bugs, leaf hopper, mole rat and porcupine) and soil nutrient depletion are some of the important production constraints to the crop in the locations in which it grows, principally in the south western Ethiopian Highlands. It is reported that up to 80% of enset farms are currently infected by EXW. Africa RISING has intiated an action research initiative on enset and its production system as the production constraints have been repeatedly mentioned to us by farmers, development actors, researchers and policy makers as a priority research area for our southern region field site at Lemo. There is good evidence that EXW is:

- reducing enset yield and quality;
- the loss of a single enset plant in a family would mean the loss of one man's food;
- enset is a crop that offers significant opportunities to women although it is currently constitutes a significant demand for their labour;
- the production constraints identified have relevance across enset growing regions suggesting that there is significant scaling potential;
- best bet enset production technologies and practices do exist but need further research and promotion to make them more widely useable.

Field observations and group discussions with the farmers of Jawe and Upper Gana has revealed that there is a large range of traditional knowledge and information on host clonal diversity. The various economic and cultural uses of this diversity and their interaction with the management of the pathogen are very prominent. According to farmers there are already important indications that some clones are resistant/tolerant to the pathogen. Moreover, farmers noted that the number of cultivars varied across villages. Enset production and productivity in Lemo woreda has been decreasing. Farmers claimed that the spread of *Xanthmonas* wilt in enset (Photo 2) could affect the total number of cultivars at kebele level.

In the two Africa RISING kebeles of Lemo woreda, the genetic base has already been vulnerable to a range of highly damaging biotic factors such as EXW, leaf hopper, mole rat, porcupine, and corm rot. It is the EXW which has had the greatest impact on enset production. Severe declines in cultivation, changes in cropping and dietary patterns, genetic erosion and catastrophic impacts on livelihoods have all accompanied the arrival of EXW in the areas. The good news is that there is a model for participatory variety evaluation that can potentially put much greater enset genetic diversity in the hands of farmers from the research centers, from which they can select for different agro-ecological conditions and their own preferences.

Our work is starting to identify different forms of collective actions and local institutions that can support enset disease control activity. Moreover, mobilizing the community as well as coordination of activities related to eradication of enset bacterial wilt on a sustainable basis will promotes enset production and wilt control management technologies more strongly.

Photo 2. EXW infected field

Historically, enset stands have been very long-lived and farmers often innate the existing cultivar mixtures from earlier generations. The experience of generations communicated by many farmers indicates that they appreciate that their plantations performed better and survived longer with higher levels of crop diversity. High levels of diversity afforded a variety of outputs and minimized risk through multiple cropping. This momentum needs to be maintained by Africa RISING. Cultivar diversity also reflected a variety of production objectives (for example: Kocho, Bulla, Amicho, Fiber, disease tolerance) and differential performance these and the stresses that the crop has been subjected to. These observations further indicate the importance of cultivar diversity for food security and sustainable cropping systems.

Research highlight: Pilot study on supplemental irrigated fodder production for fattening sheep

Small scale irrigation (SSI) practices are vital to the intensification of crop-livestock mixed farming systems in the Ethiopian highlands. Farmers in the Africa RISING sites have different levels of access to irrigable water, ranging from shallow wells to streams and rivers. Harnessing these water resources for irrigation is expected to diversify the income of farmers and improve their livelihood in a sustainable manner. As feed is the number one constraint for livestock production in the highlands, production of supplemental green fodder using irrigation appears to be an alternative solution to minimize feed scarcity during the dry period. This research protocol, conducted in collaboration with our USAID-funded Innovation Laboratory on Small Scale Irrigation (ILSSI) aimed to assess the feasibility of producing irrigated fodder which can supplement the ration of fattening animals and improve the income of farmers from the fattening practice.

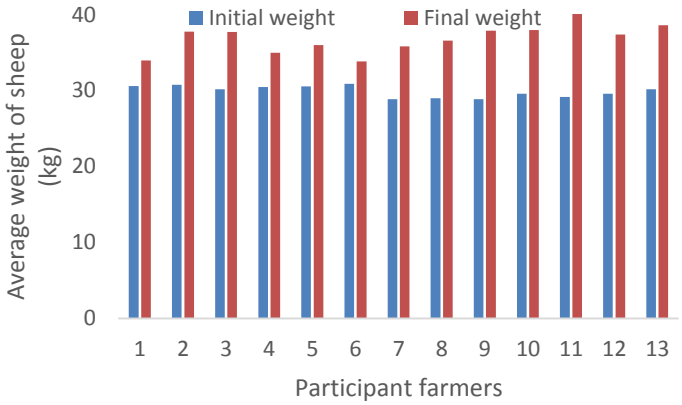
The study was in the Lemo site with a total of 14 farmer groups (of which 3 were woman headed HH) from Feb to August 2014. The farmers used shallow wells and manual water lifting pumps to produce irrigated oat/vetch fodder on plots of ≥25 m^2 each. The amount of fodder biomass produced ranged from 2.3 to 4 ton/ha. Farmers used the irrigated fodder as a supplement to feed to fattening sheep (5 sheep each, which they purchased with a loan provided by the project). In the middle of the fodder production and fattening periods, field days (experience sharing events) were organized. Farmers provided their feedback on the use of SSI for fodder production and intensive sheep fattening. They stressed the importance of improved water lifting technologies (eg. rope and washer pumps rather than treadle pumps) to expand SSI. The majority of participants said that fattening five sheep at a time was labor intensive, which they considered as a disadvantage. Two groups of farmers emerged at the end of the trial. The majority preferred to shift to cattle fatting, mentioning that a bull can be fattened with less labor, less feed, and yet comparable profit to that of 5 sheep. The other groups preferred to continue with sheep fattening, but with less number of sheep (1-2) at a time.

The mean initial weight of the sheep was 29.5 kg/head, and after 3 months of feeding the mean final weight was 37 kg/head (Figure 1). The farmers sold their sheep during the Ethiopian New Year holiday. The price of sheep, however, fell from 43 ETB/kg live weight in April 2014 (Easter Holiday) to 30 ETB/kg LW in September (New Year Holiday), and this had a negative impact on the profitability of the fattening trial. An important observation in this case is that marketing time and market links are crucial for the profitability of the fattening practice.

There were considerable differences amongst individual farmers in their capacity to manage fodder plots and fattening animals, with female headed households generally performing better. This variability was reflected in the amount of biomass harvested and in the final body weight of sheep fattened. The farmers learned lessons from one another's practices during the field day visits, group discussions and trainings (Photo 3). Following the pilot trial, new farmer groups were formed in the 8 Africa RISING kebeles, with each group comprising 20-25 households. The new groups planted rain fed oat/vetch fodder on plots of ≥100m^2 in preparation to the next irrigated fodder/fattening research during the dry period.

Photo 3. Farmers visiting irrigated fodder plots, attending training on irrigated fodder production and operation of rope and washer pumps

Figure 1.Average initial and final body weight of sheep fattened for 3 months using irrigated oat/vetch fodder as a supplement



Integrating SSI with livestock production can have a significant impact in the income of farmers. The water productivity can also be improved if fodder production and improved livestock management practices are considered simultaneously. Irrigated fodder production can be carried out alongside vegetable production or other crops, and the biomass produced through irrigation (fodder, non-edible vegetables, and crops harvested green) can serve as a good source of supplementary feed. Commonly, crop residues are the main source of feed for ruminant livestock in the highlands. These crop residues have low digestibility and nutrient contents, especially nitrogen. Supplementing such basal diets with green fodder is expected to compliment the nutrient deficiencies, improve the productive performance of animals and hence income of farmers. Through this pilot trial awareness was created among farmers to expand SSI in general and irrigated fodder in particular.

Supplementary SSI practices minimize risks of crop failures and improve farmers' resilience to shocks of unpredictable rainfall patterns associated with climate change. As livestock are an integral part of the mixed farming system (providing farm power, animal protein (food), cash income and manure) and feed is the major input required for livestock, production of fodder using SSI will increase the systems productivity as a whole and help improve the food security and nutrition of farm households.

Research highlight: Integration of high value multipurpose trees with soil and water conservation

The diagnostic activities (participatory community analysis, local knowledge surveys) conducted at the Africa RISING research sites in 2013 identified considerable interest among farmers in the production of high value crops such as fruit trees. Temperate fruit trees (avocado, olive, apples) represent an untapped opportunity in the high lands of Ethiopia for intensification and increased market participation by small scale farmers. The Africa RISING research protocol on high value crops is a collaborative effort by ICRAF, ILRI and IWMI to select superior fruit tree cultivars with high yielding varieties and determine and alleviate the constraints to their wider adoption. Under the protocol, six high yielding varieties of avocado (Hass, Furete, Nabal, Bacon, Pinkreton, and Ettinger) - which can grow well in the Southern and South western parts of Ethiopia - have been introduced at the Lemo site. These varieties can yield fruits after only two to three years. The cultivars are propagated vegetatively through grafting originated from superior seedlings. The research team is also engaged in raising awareness of the potential of apple trees in three regions (Amhara, Oromia and Tigray), including the introduction of different varieties. Prior to seedling distribution farmers' training on pre and post-planting tree management was organized. The trainings were held in the fruit tree nursery of Ministry of Agriculture (MOA) in Butajira in May 2013 and in Debre Birhan in June 2013 (Photos 4 and 5). In this training 80 farmers were participated from two kebeles in Hosana

area. For training on Apple tree, 50 farmers and development agents from the three woredas were transported to Debre Birhan. The central objective of this farmers' training were to provide theoretical and practical training on pre- and after-planting management to:

- Increase farmer understanding on fruit trees such as Avocado and Apple and their role on achieving household food security and nutrition;
- Provide important information on environmental and resources requirement of the planted fruit cultivars e.g. watering, manure, selection of crops best matching with the planted fruit trees etc.;
- Equipped farmers with planting and early care of fruit trees (e.g., hardening off, avoiding sun burn before planting, removing the plastic cover during planting, planting pit preparation, and plant spacing);
- After planting management of grafted seedlings such as, timely pinching of unwanted new buds at the root sucker (below the grafted union), watering, fertilization, protection from animals; and
- undertake exploratory surveys on existing fruit trees and related issues through formal and informal discussions.

The outcomes of the farmer training included:

- For more than 130 farmers, knowledge and skills on how to plant and manage fruit varieties has been improved.
- Mortality of planted fruit seedlings has been reduced
- Farmers have been familiarized with how we hope to improve food and nutritional security through the medium of high value fruit tree production over the next three years.

Photo 4. Field demonstration on how to plant and untie the plastic tie from the grafted point

Photo 5. Field demonstration was organized to Fiji private fruit farm in Debre Birhan (left) and Butajira Nursery (right) to inspire farmers to plant apple and Avocado trees, respectively

The project also conducted on-farm plantation activities (research trials):

- About five hundred improved avocado seedlings were planted on farmers' field in Hosana zone. The project provided six seedlings to each participant. The planted seedlings were fenced and tagged. Survival and growth performance of the planted seedlings is being monitored at three-month intervals. A mixed blessing perhaps but one female farmer reported that two of her planted seedlings were stolen from her back yard indicating a very high demand from her neighbours.
- Similarly, highland temperate fruit planting were carried out at three sites. In total 1,500 improved apple tree seedlings were planted 500, each site (50 farmers × 10 apple seedlings / farmer / site). Before distributing the seedlings, farmers were familiarized with appropriate management practices and survival and growth performance is being monitored every three months (Photo 6).

Photo 6. Monitoring of the planted seedling by the research team

In addition to the on-farm trials the protocols have established experimental plots at the farm of a private investor in Debre Birhan and greenhouse experimental plots in Holeta research centre. These are being used to study the following research topics in greater depth (Table 3).

Table 3. Detail on research topics and sites for basic research on apples

Detailed research topics	Type of the research	Site
Site suitability study (soil characterization, soil fertility, niche preference, temperature (chilling unit) and climate matching) for different Apple varieties	Field observation, field measurements, green house and laboratory based	Sinana, Hosana, Debre Birhan, and Tigray and Holeta research center
Site suitability study (soil characterization, soil fertility, niche preference, and physical requirements) for improved Avocado varieties	Field observation, field measurements, and laboratory	Hosana
Dormancy breaking through leaf defoliation and timing for Apple trees	Field observation and measurements	Debre Birhan / Ato Abyi farm
Growth and yield performance of different avocado/apple varieties	Field observation and measurement	Sinana, Hosana, Debre Birhan, and Tigray (FTC/Debre Birhan University farm)
Stomatal conductance and response to environmental stress and management variables, e.g. irrigation (water), fertilization, pruning etc) of Apple	Field observation and measurement, laboratory	Debre Birhan/ Ato Abyi farm
Pruning and pinching requirement of Apple tree (best pruning season, pruning frequency, average branch number need to be removed in relation to age)	Field observation and measurement	Debre Birhan / Ato Abyi farm and on farm
Inflorescences removal of premature avocado trees and subsequent yield increment	Field observation and measurement	Butajira fruit trees nursery site and on-farm research
Soil fertility and apple fruit quality: implication for satisfying household nutrition requirement and market requirement	Field observation and measurement, laboratory	Debre Birhan/ Ato Abyi farm and Addis Ababa University nutrition laboratory
Molecular studies on draught stress ability of different Apple varieties (DNA marker extraction, proteomic and biochemical analysis)	Laboratory	Addis Ababa university/ Nairobi-ICRAF laboratory
Propagation ways (grafting and budding) to improve lateral and leading shoots and yield of Apple tree on different rootstocks	Field observation and measurements	Debre Birhan / Ato Abyi farm/ Debre Birhan University farm
Baseline survey	Socio-economic study	Sinana, Hosana, Debre Birhan, and Tigray
Adoption of improved avocado and apple varieties by smallholder farmers (what are the enabling factors and constraints for adoption of improved fruit tree varieties both for apple and Avocado	Socio-economic study	Sinana, Hosana, Debre Birhan, and Tigray

The project includes support for PhD researchby Abaynhe Melke on:

- Eco-physiology of winter chilling temperature requirements for apples (*Malus domestica Borkh*) grown in some Ethiopian highlands: Comparison of Chill Unit Models Validation
- Use of artificial dormancy braking treatments to compensate incomplete chilling in apples *(Malus domestica Bork.)* for better flowering and fruit setting under tropical highland conditions
- Evaluation of rootstock-scion compatibility of apple (*Malus domestica Bork.*) cultivars grafted on M-7 semi-dwarf rootstock: Comparison of budding and grafting techniques.

Finally, yield performances of 4 apple varieties were assessed at the existing private fruit farm. The low-chill cultivars (Anna and Princesa) showed better yield than medium chilling type cultivars (Gala and Permicia). The average yield harvested from Anna cultivate was 10 kg tree^{-1} followed by Princesa

(8.5kg), Gala (6kg) and Permicia (5 – 6kg). Better fruit colour, size weight (90 g) was found for Anna. This indicated that low chill cultivars grow well in most highlands of Ethiopia.

Research highlight: Crop residue utilization and management

In the mixed crop-livestock farming systems of Ethiopian highlands, livelihoods of 67% and 30% of the households rely on crop production and livestock production respectively. Off-farm businesses contribute approximately 3%. Economic activities around livestock production are draft power, fattening and dairying of local cattle, dairying of crossbred cattle and sheep fattening. Shortage of feed has emerged as one of the major constraints for livestock production in the highlands. This is partly due to the continuous conversion of grazing lands to arable lands to meet the increasing demand for grains. Due to the diminishing role of grazing as a source of feed in the mixed farming system, crop residues (CR) have become the major source of feed, contributing 30-80% of the total feed dry matter available to animals. This is particularly so during the dry season when green feed biomass is critically in short supply. The CRs are comprised predominantly of straws and hays from cereals and pulses from the growing seasons. Eight research groups have already been formed in the four sites for participatory evaluation of techniques to improve the utilization of crop residues by farm households. However, prior to this evaluation, a survey was conducted to assess the production, management and utilization of crop residues as well as preferences and perceptions of farmers on the use of crop residues as feed. A total of 258 households drawn from the four sites were interviewed using semi-structured questionnaires.

Varietal preference

The farmers in the studied area are entirely smallholders with an average land holding of 3.9 hectares. The land is divided into an average of 3-5 plots, each plot sown with a different crop. Almost all farmers grow at least one cereal crop, vegetables and pulse crops. The major pulse crops are faba bean and field pea, grown by 68% and 50% of the farmers respectively. Lentil is only grown by 18% of the farmers. The varieties grown are predominantly local. Only 30% of the faba bean and field pea is improved variety while 40% of the lentil is improved variety. Perceptions of farmers to the use of improved varieties as livestock feed came out as interesting as most farmers mentioned that improved varieties of pulses are rejected by the livestock, therefore they still grow local varieties and adopt improved varieties only to a limited extent.

Utilization

CR was reported as vital for livestock feeding by 97% of the farmers. The trend of utilization of CR as feed has been increasing over the past 5 years. 78% of the farmers reported increasing use of CR for stall feeding while only 3% of the farmers burn their CR. About 70% of the farmers combine cereal straws with pulse hays for feeding, stacked into heaps, albeit at no conscious ratios. An estimated 30% revealed that they strategically feed pulse crops to lactating and draft animals because of the perceived higher nutritive value of the pulse CR.

Storage management

After harvest, farmers transport the straw and hay to the homesteads and thresh them to separate the straw and hay from the grain. 50% of the farmers reported that they store their straw by making field and home heaps in open lands while 39% of the farmers store their straws in constructed shelters near the house. Well-drained locations on higher ground are purposefully selected around the homesteads for making of the heaps. The storage process begins by mounting a layer of stones, a layer of plank and a layer of ash to protect the straw against termite and ground moisture. Thereafter, the stacked CR is placed in a circular fashion and pressed downwards by hand, feet or wood shelves from the top and sides. Layer by layer, the diameter is decreased so as to form a cone shape. When the heap becomes too high, a ladder is used to climb it. The farmers cover the top of this dome using grass or CR. The farmers believe that this method of heap making ensures that the

CR is protected against termites, ground moisture and rainfall. On average, each heap provides feed for a period of 2-3 months to 7-10 large ruminants and 2-5 small stock.

Feeding management
Farmers feed their animals from the heaps twice daily on average. They use different methods. Animals are either released to feed directly from the heap or CR is taken from the heaps, struck with sticks to remove the dust and then put directly onto the ground or into a hole in the ground. It is normal for animals to trample all over the CR and defecate on it while feeding. This leads to severe wastage and contamination although might also offer opportunities for compost making and the improved cycling of nutrients.

Straw quality enhancement
The government extension service and peer information are the main sources of information for physical treatment of CR to 96% and 53% of farmers respectively. Physical treatment in the form of chopping is the only treatment undertaken by farmers on the CRs. It is practiced by 53% of the farmers. Labour constraints were cited as a reason why CRs may not always be chopped. Chopping refers to physically breaking of the CRs by hand or striking them with sticks to break them. 15% of the farmers have received information on chemical treatment (urea treatment) from government extension workers, but there is no uptake because of the perceived expense, although most have never tried. In most cases, dietary supplementation of the CRs is rare especially during dry periods. Occasionally, vegetable residues (potatoes, cabbages, carrots) are additionally fed during the growing seasons.

Livestock preferences for local crop varieties may have an overall consequence on adoption of improved higher yielding pulse varieties. This presents an opportunity for socio-economists and livestock nutritionists to comprehensively determine underlying factors affecting adoption of high yielding crop varieties. It is also an opportunity for crop breeders to view intensification of pulse crop-cereal crop intercropping or crop rotation not solely from the point of view of their potential contribution to human food supplies, but from the perspective of the cropping system's contribution to animal feed. Crop breeders need to work with livestock nutritionists to determine food-feed traits of pulse and cereal crops.

It is evident that farmers make concerted efforts to protect the crop residue heaps against problems like termites and moisture, however, how successful are they? Deterioration due to storage can only be assumed for now but nutritional testing will be used to ascertain its extent. Sequential collection of samples from the heaps and consequent nutritional analysis to determine the level of deterioration due to storage is currently ongoing from CR heaps of 25 farmers in Debre Birhan (Photo 7). Farmers are very keen to know results of the analysis during every monthly sampling.

The current feeding method of CR leads to a lot of feed wastage and spoilage. The ongoing introduction and testing of simple and cost effective feeding technologies in form of storage facilities, feeding troughs and choppers will go a long way into reducing feed refusals and overall pulse and cereal CR losses. The participatory approach of actively engaging farmers from problem diagnosis to technology transfer is vital to sustainable uptake of improved practices. There is also need to sensitize the farmers on supplementation of the CR using locally available agricultural and agro-industrial by-products for enhanced livestock productivity. Feeding strategies using these alternative feed resources need to be developed and feeding packages introduced to farmers.

Crop residues from the farmers' growing season provide enormous opportunities for improving the current level of production from ruminants, thus intensifying sustainable the crop-livestock system of the Ethiopian Highlands.

Photo 7: Residue from a good crop in the field is preserved for livestock feed in form of stacked

Research highlight: Learning about adoptability from technologies in use

This study involves a historical survey of the factors governing adoption of existing technologies and management practices in mixed crop-livestock systems and their implications for identifying future, adoptable interventions.

Livestock fodder management was one of the technologies selected for the study after consultation with local development agents. Farmers were consulted about feed resources for grazing and stall feeding, their year-round availability and livestock consumption preferences. Lemo was found to have the most diversity in resources for stall feeding sources with four principal fodder management technologies practiced widely (Table 4).

Table 4 Adoption of livestock fodder technologies on each site (√ indicates technologies practiced by >100 farmers in both of the target woreda, according to development agents and woreda records).

Technology	Endamahoni	Lemo	Basona	Sinana
Late weeding of crop fields for fresh grasses and hay production	√	√	√	-
Improved fodder varieties incorporated into agricultural land	-	√	-	√
Tree fodder grown on boundaries and marginal land	-	√	-	-
Crop residue collected during threshing and fed throughout the year	√	√	√	√

Late weeding
Because of the shortage of available grazing land (particularly in rainy seasons) farmers leave the grass weeds on their fields until closer to harvesting time to utilize as livestock feed. These weeds are fed both as fresh grasses and stored as hay and fed to animals later in the year. This technology was common to three of the four sites. In Endamahoni late weeding was practiced by 95% of the farmers surveyed; in Lemo 90% of farmers and in Basona 91% of farmers. In Sinana landholdings are significantly larger so farmers used herbicide on the weeds rather than collecting them by hand and only 16% of farmers surveyed utilized grass weeds as a feed resource.

Local names of the common weed species were collected and, where possible, scientific names were identified. In Endamahoni farmers mostly utilized three to four species of weed (including *Festuca richardii*). In Lemo, 10 grass and broadleaf weed species were identified by farmers, the most palatable was "muja" or *Beckera polystachya*. In Basona three species were named by farmers. In all three sites farmers ranked the grass and weed species as highly palatable (see Figure 1), with the majority of farmers ranking them first or second. The palatability was mainly attributed to the fact they are fed fresh to the animals and are softer and easier to digest than crop residue.
Trade-offs between the increased access to forage resources offered by the late weeding strategy and compromised crop productivity is being explored as a case study in our research on stepwise integration strategies.

Improved fodder varieties
Only Lemo and Sinana were found to have widespread adoption of improved fodder types. In Sinana as landholdings were large farmers would grow different varieties of improved forage oats on strips of agricultural land. In Sinana 86% of the farmers surveyed grew forage oats. Seed was obtained from Sinana agricultural research centre and then sold locally. Farmers were keen to expand the community seed production of forager oats as the varieties grown were considered highly palatable (see Figure 1).

In Lemo over 50% of farmers interviewed grew "Desho" grass (*Pennisetum pedicellatum*) on soil bunds and field boundaries for erosion control and provision of livestock fodder. Other improved fodder species were found (*Tripsacum andersonii*, *Desmodium spp, Pennisetum purpureum* and *Chloris gayana*) but in low frequency. Desho grass was considered highly palatable (Figure 2).

Tree fodder
In Lemo farmers have more successfully moved into a zero grazing system, and so exploited marginal niches around crop fields more successfully than in the other sites. Farmers typically retain a diverse range of tree species along field boundaries and use them as demarcation. A total of 18 tree species were identified as fodder trees, the most commonly utilized were *Vernonia amygdalina* and *Adhatoda schimperiana*. 37% of farmers surveyed used their boundary trees as livestock fodder, though most species were not highly ranked for palatability (Figure 2). Farmers in Lemo also grew Enset as a staple food crop. Enset and banana were utilized as livestock feed by 68% of the farmers surveyed, and Enset was listed as highly palatable to animals (Figure 2).

Further exploration in this study will focus on gender disaggregation for livestock feed ranking to test priorities for male and female farmers and timing of the availability of livestock feed sources, including grazing sources.

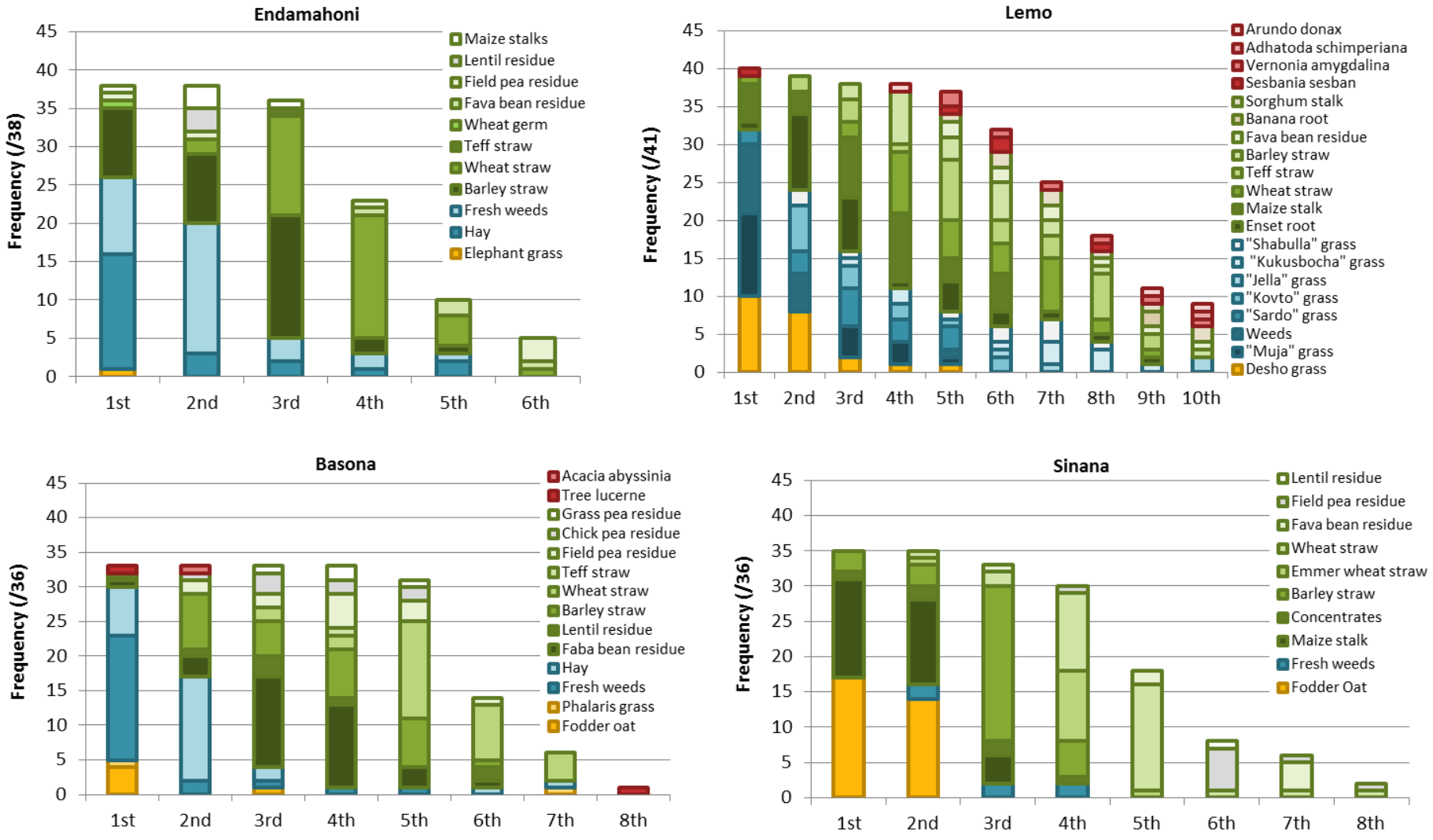


Figure 2. Ranking on the palatability of livestock fodder types according to local knowledge. KEY: Yellow = exotic fodder grasses, Blue = indigenous weeds collected from cropland, Green = Crop residues and straws, Red = Tree fodder.

Research highlight: Redesigning cropping systems to improve nutrition, income and food security

Food shortages in Ethiopia have been taken to be a function of limited access to food and has rarely been seen as a function of non-balanced nutrition. Malnutrition of vulnerable groups (children and women) could occur even in good crop harvest years because of unbalanced food intake. Food nutritional quality could be improved through different practices such as consuming livestock products, application of fertilizers and soil amendments, selection of varieties with high micronutrient content, and use of indigenous high nutrient value crops. However, animal products are rarely consumed at the household level as they are deemed to be more important as a source of scarce cash. Dietary supplements are also rarely available to the rural poor. One affordable option to minimize the risk of malnutrition is through the reallocation of cropland in favor of crops with the potential to address the nutrients that are in deficit. In this case, analyzing households' production of nutrients on farm could be valuable in guiding intensification of those systems in which markets are less important than securing subsistence.

We have been analyzing the current nutritional status of the cereal-based system at one of the Africa RISING sites, Debre Birhan (Gudo Beret). Barley and wheat are currently the major staple crops. Preliminary results showed that, on average, the current production system was not in a position to satisfy human nutrition both in quantity and quality of the required nutrients. However, resource-rich farmers were in a position to cover their energy, protein, zinc, and thiamine demand, while their system is in deficit of calcium, Vitamin A and Vitamin C, which was as low as 30, 2.5 and 2% of the recommended daily allowances. Preliminary analysis suggests that a shift in the cropping system by reducing the area under barley by about 35% and expanding the land area planted to legumes (Faba bean/ pea) by 16% and integrating more vegetables (particularly Ethiopian kale, fruits and oil crops) could be beneficial to household nutrition. As the area is frost-prone, there is also the possibility of expanding subtropical fruits (e.g. apple) to supplement the vitamin and energy needs. The project plans to use these results in negotiation with the community to facilitate change towards a more food secure landscape.

Research highlight: Improved crop management practices to address yield gaps

Matching crop-specific fertilizer regimes, including types and amounts, with local soil and seasonal climate conditions coupled with the use of improved crop varieties has the potential to greatly reduce the existing yield gaps in project sites. On-farm demonstration and experiential learning where farmers experiment on their own fields with 1 or 2 selected practices can result in widespread adoption and adaptation of technologies. By applying the principle that yield is a function of genotype, environment and management, we seek to move farmers from the current practice of low input use to a profitable use of improved seed and optimal fertilizer amount adapted to varied local conditions. Accordingly, we have been testing impact of different fertilizer types with different rates and application of manure on the yield of wheat, barley, faba bean and potato in different AR project sites. This short highlight is based on observations from experiments at Gudo Beret kebele of Debre Birhan site.

Most farmers in the area apply DAP and Urea to their wheat field, but not at the recommended rate. In addition, farmers rarely practice row planting and they do not remove weeds as required (some possible reasons for farmers' resistance to timely weeding are discussed elsewhere in this report) . The current trial includes recommended rates of N, P, K, S and Zn. The amount of input use depends on recommendations for Ethiopia in relation to each crop. Additionally, manure use was integrated with the use of these inorganic fertilizers. The seeds were sown with recommended inter and intra row spacing. Every treatment was weeded as required.

We have observed that there is clear difference in wheat stand performance between the different treatments, those with recommended packages look much better than those plots without fertilizer. Besides, with this experiment, we observed that wheat crop stands looks better on plots where manure is integrated to inorganic fertilizers. On the same wheat field (Fig. 1), there is clear difference in wheat performance between farmer's practice (Photo 8A) and our experimental plots with recommended package (Photo 8B).

Photo 8. A field showing different responses of wheat to different management inputs. The photo was taken two times, but the different responses shown here are on the same field. 'A' is not weeded and has no fertilizer, it is farmer's practice. 'B' has got recommended fertilizer package, and also manure. 'C' has no fertilizer input but weeded as required.

Generally, we observed two cases with our experiments on wheat at Gudo Beret of Debre Birhan. On three experimental fields, farmer's practice looks competitive with our plots with the half recommended package (Photo 9). In this scenario, although we didn't survey how much amount of fertilizer they applied, we were able to see that weeds were managed in similar manner as in our experimental plots. While farmers sowed their wheat by broadcasting, our plots were planted in row.

Photo 9. A field with first scenario. A is our experimental plot with recommended management inputs, and B is farmer's practice.

The other observation is related to five farmers' wheat fields which were poorly managed. They didn't weed or plant in rows. In these fields, very poor performance of wheat is observed.

Due to a combined effect of variety, input use and agronomic practices, all our fields generally showed better performances compared to surrounding farmers' fields. Such a difference can be easily visualized from a distance. The experimenting farmers themselves have been impressed by the wheat crop response to the combined effects of the variety and the management inputs. We asked a farmer about his feeling on the wheat experiment conducted on his field. He stated "Despite my involvement with researchers for many years, I have never seen such a tremendous performance of wheat crop as in this season with this experiment".

There are indicators that those with improved packages like improved wheat, weeding, row planting and right amount and timely application of N.P.S, K and Zn containing fertilizers could potentially improve wheat and potato yield. Although it could be difficult to put forward the final conclusion as we need to have the actual yield and soil data in order to indicate future research directions based on what we have observed. These could include:

- Conducting weeding experiment (including time and rate of weeding): Weeds look still highly limiting the yield potential.
- Introducing wheat row planting and row planter technology to the area (especially at Debre Birhan)
- Piloting scaling of Tsehay variety (at Debre Birhan) with its recommended package since it is resistant to rust, other varieties have been affected by the same disease.
- We observed our wheat experiments at all fields are not equally responding to the applied fertilizer type and rate. This will require understanding the soil health condition and develop management and input use options for non-responsive soils.
- Test the newly recommended ATA fertilizer rates for different crop and soil types in relation to the existing DAP and UREA recommendation
- Considering the trade-offs that may prevent farmers' from actually adopting practices that demonstrably increase productivity of their crop land, for example, loss of feed resources due to the adoption of early weeding.

The current technology addressed a few farmers (8) per site. Therefore, to realize the technology impact in the kebele or Woreda, further scaling strategy needs to be designed with the promising technology options. We may have different recommendation options (domain) to different typologies of farmers and farming conditions based on the result from the economic analysis.

Research highlight: Facilitating establishment of pilot potato seed businesses linked to producers

To address problems and opportunities on seeds and output markets, the Africa RISING Ethiopia project is implementing pilot seed businesses via innovation platforms and other key partners. The pilot seed businesses are meant to supply quality seed that is necessary to sustain high productivity among the farming communities through action research approaches. The intervention is fills a gap in the current seed systems where the private sector is missing, slow or unwilling to invest in the seeds sector especially for self-pollinated or propagating crops. For the case of potato, a sustainable seed enterprise would be able to contribute to increased potato production and consequently food and incomes for the households.

Recent value chain studies in the project sites have brought out a major challenge facing potato commodity enterprise to be lack of consistent supply of planting materials. In the current interventions, farmer-based agribusinesses (primary cooperatives, unions, and other farmer groups or associations) are supported to take on seed business in order to supply potato seeds to

producers. The capacity of the agribusinesses in the areas of profitability determination and management of the seed businesses will be enhanced. The capacity building includes participatory market research skills. The businesses are also facilitated to prepare seed business plans to produce seeds of preferred potato varieties. The seed businesses will be linked to target markets (other producer organizations and seed enterprises). Linkages will also be established between the farmer agribusinesses and market services such as credit to support their enterprises. The impact of seed businesses on seed availability and utilization will be evaluated at the end of the second year.

Insights from recent value chain assessments on potato in the research sites indicate that the key challenges facing the potato traders, apart from seeds, include storage and post-harvest management, which are cited by almost 54% of the potato traders. Besides storage problems, the inability to access good supplies of potato was also observed and affected more than 50% of the potato traders. In addition, more than 51% of the traders were not assured of good supplies of potato. At least 53% of the potato traders were able to find good markets for their potatoes. Most of the traders also cited strong market linkages and linkages with other actors as key to addressing the challenges identified in the potato value chains. Currently, the linkages are weak: there were few explicit contracts between traders and suppliers (less than 11% overall). Furthermore, while 53% of the traders sold products on credit, only 25% ever bought the potatoes on credit. Thus opportunities lie in enhancing potato supplies and improving the quality of the potatoes through reliable seed systems and capacity building. The survey results indicated that less than 14% of the traders ever received any training on handling their products, a factor that can be observed in the extent of poor post-harvest management of the potatoes.

The implications of these results for the AR project point to the need to establish collaborations between seed and output traders on one hand and with producers on the other. Indicators of good collaborations include use of contracts in trading relationships. This indicator is quite low especially the interface between the trader and the producer; and this is an area that needs to be strengthened. The capacity of traders also needs to be improved for the benefit of better linkages with farmers. It also implies that in the innovation platforms that have been established, good representation of the input and output traders need to be maintained to ensure faster uptake and sustainability of the new productivity enhancing technologies and practices. Partnerships between the supply agribusinesses and potato producers in the framework of the AR project are one of the key implementation pillars. In every project site and innovation platforms, at least one output trader and or input supplier have been identified to be part of the innovation platforms that have been established. The project will also demonstrate a clear link between seed enterprises and the potato output enterprises in the project intervention areas and seek to measure the results of the interventions.

The research contributes to the USAID's focal areas of inclusive growth in agriculture by contributing to increased production of potatoes and consequent increase in income for the producers and farmer agribusiness. A focus on promoting rural based agribusinesses and establishing linkages to inputs (credit and access to good quality seeds) and product markets are necessary to achieve this goal (Figure 3). The research in Ethiopia targets this interface.

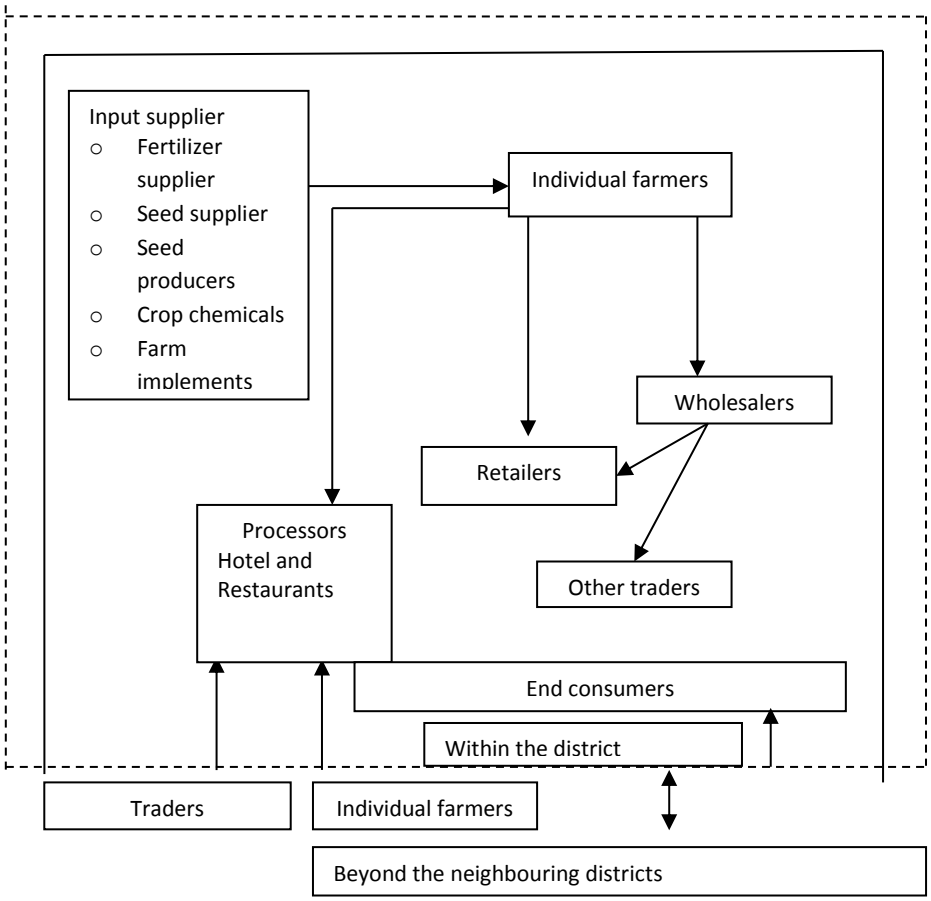


Figure 3. An illustration of potato value chains in the Ethiopian highlands

Research highlight: Enhancing food security and environmental stability through water and land management

Land degradation (soil erosion and nutrient depletion) is among the major factors contributing to declining land productivity and food insecurity in many part of Ethiopia. Integrated land and water management options can help improve land and water productivity. As part of the Africa RISING project, partners from CIAT, Mekelle University, ICRAF, ICRISAT, ILRI, IWMI have joined forces to improve land productivity and water availability through integrated interventions at different levels. The main goal is to enhance sustainable availability of water through improved development and management options. As part of this exercise, water yield, suspended sediment and soil loss assessments were conducted at landscape and plot scales at the Debre Birhan (DB) and Maichew (MA) sites. To demonstrate the potential of SLM options to enhance water resources and reduce land degradation, water yield and suspended sediment estimations were made at 'treated' and 'non-treated' sites at plot and landscape scales.

At the landscape scale, two watersheds were selected to monitor the water and sediment yield at the DB site (Figure 4). The first watershed is about 16.02 hectares of land and dominated by cultivated land without significant soil and water conservation interventions. The second watershed is about 33.27 hectares of land and the dominant use is arable cultivation with soil and water conservation measures in the form of terracing. Water and sediment yields were measured at two hydrological stations installed at the outlet of both watersheds.

Figure 4. Gauged watersheds that are monitored for water and sediment yields

The results results show clear differences in water and sediment yields between the two treatments.

1) The total discharge was about 87,788.82 and 103,441.6 m^3 for the unconserved and conserved watersheds, respectively. The water yields of the unconserved and conserved watershed was about 5,480 and 3,109 m^3 per hectare of land, respectively. Water yield of the conserved watershed was smaller due to the fact that some of the water is retained in the watershed for subsquent base flow.
2) The daily results showed that most of the discharges occured during rain events in the unconserved watershed. On the contrary, much more uniform discharge with minimal fluctuation occurred in conserved watershed (Figure 5). Over the 46 day period reported here, the suspended sediment yield of the conserved watershed was about 30.83 tones while that of the unconserved watershed was about 87 tonnes. Despite its smaller catchment area, the suspended sediment yield of the unconserved watershed was about three times that of the conserved watershed.
3) The study showed that there is enough water in the area during rainy seasons, a statement that we have heard many of our farmers make, and improved soil and water conservation practices can significantly improve water retantion capacity of the watershed.
4) Runoff expermental plots setup to evaluate the effect of different land use and management on runoff and soil loss at plot level at the DB site also showed that highest runoff and soil loss (2.4 tonnes) was recorded form unconserved, cultivated land (Figure 6) while conserved, cultivated area experienced much lower (<50%) soil loss.

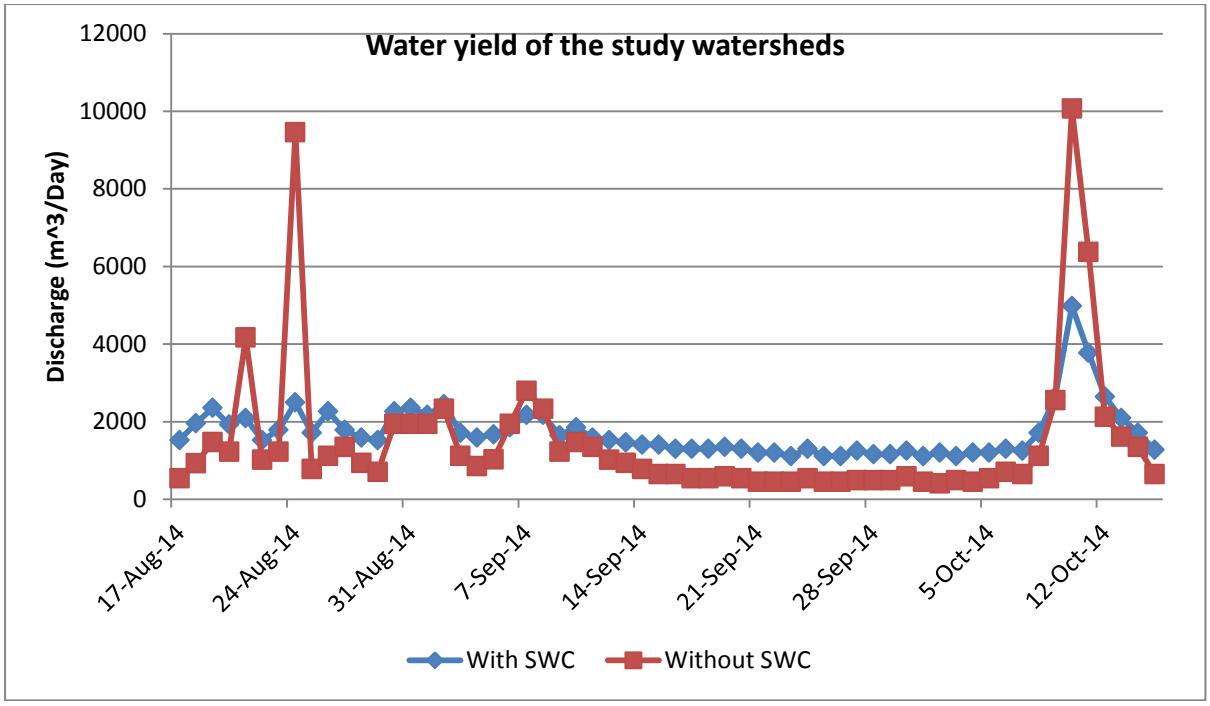


Figure 5 Water yield of the study watersheds

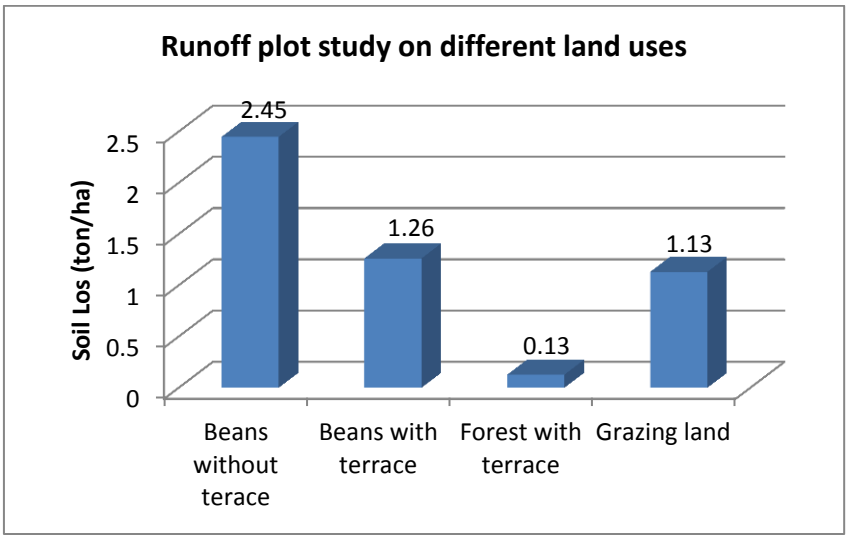


Figure 6 Soil loss as affected by different land use and management practices (a) for one of the plots, and (b) for average of all the plots

5) Sediment analysis collected from five streams within the catchments of the MA site revealed variable sediment concentrations: samples collected from the upper sections of the catchments (site 1 and 2) revealed relatively lower sediment concentrations (1.6gm/litre to 5.1gm/litre). Water samples from lower sections of the catchment (sites 3, 4 and 5) resulted in highly variable but relatively higher sediment concentrations (7.1gm/litre to 46.7gm/litre).
6) Siltation assessment of some hydraulic structures, mainly a diversion which is planned to irrigate 150 ha of land, revealed that the diversion weir (e.g. Photo 10) was silted up in less than a year with an estimated volume of sediment of about 6,520m^3. Siltation is seriously affecting the irrigation schemes at downstream area. Due to such problem several check-dam ponds are not functioning as intended.

Photo 10. Examples of diversion weirs used to divert stream flow for irrigation purpose in the study sites

7) One of the major check-dam diversions (Photo 11; constructed close to Maichew town) to irrigate about 150 ha of land downslope is silted-up in one year due to sediment from the upstream catchment. A pump house (at upstream of the main check-dam diversion) is also silted-up with sediment and is no longer functional.

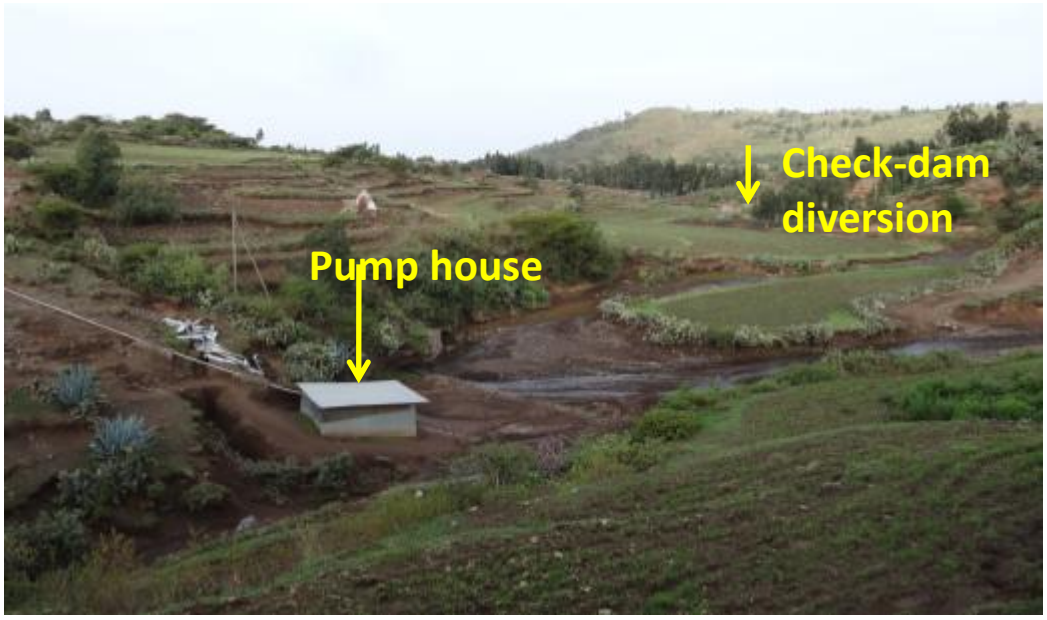


Photo 11. View of the pump house and downstream check-dam diversion affected by siltation problems in Maichew site

The key findings of this preliminary study include:

a) For sustainable intensification to be successful at farm and plot scales there is a need to identify, develop and promote improved land and water management options in a participatory manner.
b) The results showed that with improved land management practices at different scales, it is possible to increase water yield and reduce erosion as well as siltation.
c) With better land management options, it should be possible to promote water harvesting approaches that can enhance productivity through irrigation. It is possible that springs can develop in many parts of the sites which can be used for irrigation purposes as observed in Tigray. However, there is a need to enhance their discharge through upstream treatment (mainly construction of soil and water conservation structures, check-dams and percolation ponds). This should be carried alongside improved groundwater recharging options as several of the hand-dug wells in Maichew do not yield enough due to depletion of water.
d) There is a need to conduct comprehensive evaluation and modeling of the erosion risk and its management strategy including evaluation of the terrain characteristics, land use/land cover, major rock/soil units, and monitoring of sediment and runoff at selected stations.
e) It is important to evaluate water related issues and development of water resources development strategy for the AR catchments, including assessment of the existing water harvesting practices, evaluation of the major geo-hydrological units, and identifying best water harvesting options at different sections of the landscape in the study sites.
f) Capacity building through training and experience visits of farmers, community leaders and experts working in the different sites can help share experiences in addressing issues of water and erosion problems in the areas.

Research highlight: Developing capacities for gender responsiveness in agricultural programs

To get a deeper understanding of the local context surrounding mixed farming systems, intensification, gender gaps, norms and agency, it is important to have trained researchers and local personnel who are able to collect, analyse and interpret sex/gender-disaggregated data and understand the local culture and sensitivity of the topic. The gender capacity development protocol aims to enhance the capacity of project implementing partners and local staff to collect, analyze and interpret sex/gender disaggregated data; conduct a gender analysis and use the data to address gender-based constraints in agriculture. Gender capacity development also exposes partners to the gendered approach of analyzing agricultural value chains and applying appropriate strategies when interacting with men and women. This will contribute to the design and implementation of interventions and technologies that directly respond to the needs of men and women.

A gender capacity development workshop was conducted on Aug 18-20, 2014 at the International Livestock Research Institute (ILRI) Addis Ababa campus (Photos 12 and 13). A team of facilitators was assembled from ILRI, IWMI and University of Florida, using workshop materials previously tested in countries in Africa, Asia and Latin America, and developed under the USAID funded Modernizing Extension and Advisory Services (MEAS) program. The workshop had 43 registered participants with 23 men and 19 women. Participants included partners supporting Africa RISING project and the CG's Livestock and Fish research program. Institutions represented included: Agricultural research institutes at national and regional level, office of agriculture (woreda level), universities and colleges, Ministry of Agriculture, NGOs, ILRI staff and other agricultural agencies.

A study was undertaken with local partners in Ethiopia to ascertain the constraints that they might face to integrating gender into agricultural programming. A pre-workshop evaluation revealed that majority of male and female participants lacked knowledge and skills to use the gendered value

chain approach, lacked tools to collect sex/gender disaggregated data and skills to practically engage men and women. The post workshop evaluation revealed that various participants in the workshop had much greater familiarity and experience with gender especially among the female participants. However, both male and female participants clearly needed further support, training, and assistance to translate gender into practical changes in their work. Analysis of the pre and post workshop evaluations indicated a larger percentage change among both male and female participants on aspects related to applying gender analysis tools, gender mainstreaming, how to engage mixed and single gender groups and using a gendered value chain approach. However, the percentage change seemed to be higher amongst the male compared to the female participants. Female participants made greater progress with applying the gendered value chain approach. At least two Gender Champions (male and female) were selected to lead to gender agenda in each action site.

Photo 12. Workshop participants demonstrating approaches to introduce new gender responsive technologies

Photo 13.Group discussions on approaches to engage men and women in agricultural programs

Africa RISING aims to identify and address constraints that create inequalities between men and women. With the acquired gender analysis skills and application of the gendered value chain approach, CGIAR staff and local partners will be able to evaluate gendered constraints and identify opportunities available to women and men to improve their livelihoods. Participants, however, expressed interest in furthering their capacity in project planning and measurement of gender impact, how to integrate gender analysis into their project cycles, and training facilitators to work with bio-physical scientists using a participatory approach. Assessment of participants' change in knowledge, attitude, skills and practices will be important in order to gauge the relevance of the training, evaluate the assessment methodology and identify challenges and areas that need to be further developed.

The Feed the Future Initiative places great emphasis on empowering women to achieve gender equity, the third Millennium Development Goal (MDG) by promoting interventions that enhance women's decision making power about agricultural production; access to and control over productive resources; control over use of income; leadership in the community and efficient time use. Proper collection and analysis of gender disaggregated data will aid understanding of gender relations (roles, responsibilities, access to and control over resources and benefits), which is of significant importance for Africa RISING to contribute to the gender equality goal. Through gender capacity development, CG staff and partners in the project will be in a better position to understand the local context, design and implement interventions that benefit both men and women, and also create an environment that fosters participation of women in agricultural research.

Capacity development

Various capacity building forums were held including field days organized for mid and end season evaluation of crops planted for community seed production schemes, participatory varietal selection and other on-farm research activities on feed and forage development and agronomic practices. The capacity building forums organized to enhance scaling of technologies and practices, facilitate knowledge exchange and innovations, and strengthen partnership.

Table 5. Participation in capacity building activities in four Africa RISING sites

AR sites	Partners	Field-days	Training	Workshops and meetings	Surveys
Basona (Amhara)	Farmers	173	119	389	105
	Extension	24	11	22	2
	Research	18	5	15	11
	Higher learning institutions	11	1	7	2
	CGIAR centres	18	7	24	3
	Others including NGOs	6	2	27	1
Endamehoni (Tigray)	Farmers	398	121	228	175
	Extension	38	12	26	2
	Research	7	7	17	11
	Higher learning institutions	5	4	10	3
	CGIAR centres	14	10	23	**11**
	Others including NGOs	3	2	28	0
Lemo (SNNPR)	Farmers	372	115	593	241
	Extension	14	13	26	11
	Research	1	5	9	21
	Higher learning institutions	0	2	6	2
	CGIAR centres	0	3	24	5
	Others including NGOs	0	2	16	0
Sinana (Oromia)	Farmers	175	86	422	86
	Extension	16	20	35	2
	Research	9	6	11	4
	Higher learning institutions	8	7	12	3
	CGIAR centres	4	0	16	3
	Others including NGOs	1	2	12	0
	Total	**1315**	**562**	**1998**	**704**

Communications and knowledge

The main communication channels supported are:

- Wiki page(http://africa-rising.wikispaces.com/ethiopia_highlands)
- Project updates on the program website (africa-rising.net/category/countries/ethiopia/)
- A monthly partners meeting in Addis Ababa
- A Yammer network with internal updates

During the reporting period, the team worked on the following activities:

- A new series of 'photo trip reports' to help document the field work with platforms and communities. The idea is to harness the power of images in a straightforward format that scientists can produce themselves in a rapid and timely way.
- Producing a limited number of other video and multimedia reports. A project video by ICRAF attracted strong interest globally and we are following this up with a video on the potato DLR work and on the project more generally.
- A series of briefs documenting the different participatory tools used in the project (especially in the diagnostic phase).
- Continuing to update the wiki and produce updates on the website (10 in the reporting period).
- Ethiopia team members were particularly active sharing news and updates in the Yammer network.
- Developing plans to establish and support knowledge centres supporting the woreda and kebele activities.

In addition, the following 18 outputs and products were registered in CGSpace during the reporting period:

Date	Citation	URL	Type
5/30/2014	Birachi, E., Hoekstra, D., Jogo, W. and Mekonnen, K. 2014. A rapid market assessment of commodity enterprises in the Ethiopian highlands: Africa RISING participatory research toolkit. Africa RISING Brief 4. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/41929	Brief
4/29/2014	Birachi, E., Hoekstra, D., Kimeu, A., Jogo, W. and Mekonnen, K. 2014. Report of an Africa RISING Ethiopia value chain writeshop, Addis Ababa, 23-25 April 2014. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/35672	Report
8/18/2014	Colverson, K., Mulema, A., Tesema, E., Ghandi, V. and Endashaw, T. 2014. Report of the 'integrating gender into agricultural programs' workshop, Addis Ababa, 18-20 August 2014. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/42336	Report
6/18/2014	Habtamu, A. 2014. Photo trip report from a visit to identify farmer research groups in the Sinana woreda Innovation Platform (Oromia), 18-19 June 2014. Addis Ababa: ILRI.	http://hdl.handle.net/10568/49653	Report
7/23/2014	Habtamu, A. 2014. Photo trip report on irrigated fodder and sheep fattening in Lemo, 23-25 July 2014. Addis Ababa: ILRI.	http://hdl.handle.net/10568/45987	Report
4/7/2014	ILRI. 2014. Africa RISING Ethiopia: 2014 work plan. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/35382	Internal Document
5/15/2014	ILRI. 2014. Africa RISING Ethiopia: Improving food security and farm incomes through sustainable intensification of crop-livestock systems. ILRI Project Profile. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/24787	Brochure

6/30/2014	ILRI. 2014. Africa RISING in the Ethiopian Highlands: Improving food security and farm incomes through sustainable intensification of crop-livestock systems. Poster, June 2014. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/33269	Poster
5/30/2014	Kuria, A., Cronin, M. and Lamond, G. 2014. Using the Agro-ecological Knowledge Toolkit in Ethiopia: Africa RISING participatory research toolkit. Africa RISING Brief 8. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/41928	Brief
5/30/2014	Kuria, A., Lamond, G., Pagella, T., Gebrekirstos, A., Hadgu, K. and Sinclair, F. 2014. Local knowledge of farmers on opportunities and constraints to sustainable intensification of crop-livestock-trees mixed systems in Lemo Woreda, SNNPR Region, Ethiopian highlands. Nairobi: ICRAF.	http://hdl.handle.net/10568/41669	Report
5/30/2014	Kuria, A., Lamond, G., Pagella, T., Gebrekirstos, A., Hadgu, K. and Sinclair, F. 2014. Local knowledge of farmers on opportunities and constraints to sustainable intensification of crop-livestock-trees mixed systems in Basona Woreda, Amhara Region, Ethiopian Highlands. Nairobi: ICRAF.	http://hdl.handle.net/10568/41680	Report
7/28/2014	Mekonnen, K. 2014. Photo report on field visits to Africa RISING research sites in Endamehoni and Basona Worena woredas, 28-29 July 2014 (Endamehoni) and 29 August 2014 (Basona Worena). Addis Ababa: ILRI.	http://hdl.handle.net/10568/49594	Report
7/23/2014	Mekonnen, K. 2014. Photo report on field visits to Africa RISING research sites in Sinana and Lemo woredas, 23-26 July 2014 (Sinana) and 1-3 September 2014 (Lemo). Addis Ababa: ILRI.	http://hdl.handle.net/10568/49593	Report
5/30/2014	Mekonnen, K., Gebregziabher, G. and Thorne, P. 2014. Using rapid telephone surveys in Ethiopia: Africa RISING participatory research toolkit. Africa RISING Brief 7. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/41927	Brief
5/30/2014	Mekonnen, K., Gebreselassie, S., Ellis-Jones, J., Hailemariam, G., Aragaw, A., Schulz, S. and Thorne, P. 2014. Using participatory community analysis in Ethiopia: Africa RISING participatory research toolkit. Africa RISING Brief 6. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/41926	Brief
8/15/2014	Mulema, A.A. 2014. Gender plan of action for Africa RISING in the Ethiopian highlands. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/42170	Report
5/30/2014	Thorne, P., Mekonnen, K., Leta, G., Lema, Z., Aragaw, A. and Hailemariam, G. 2014. Using the Sustainable Livelihood Assets Evaluation (SLATE) in Ethiopia: Africa RISING participatory research toolkit. Africa RISING Brief 5. Nairobi, Kenya: ILRI.	http://hdl.handle.net/10568/41930	Brief
8/4/2014	World Agroforestry Centre. 2014. A tale of two villages. Video. Nairobi, Kenya: World Agroforestry Centre.	http://hdl.handle.net/10568/41916	Video

Staffing

During this reporting period, the project appointed an assistant site coordinator for each of the four participating regions:

Region /woreda/kebele	Assistant Site Coordinator
Amhara /Basona Werana/Goshe Bado and Gudo Beret	Shimelese Mengistu
Oromia/Sinana/Salka and Ilu-Sanbitu	Endeshaw Tadesse
South Tigray/Endamekoni/Emba-Hazti and Tsibet	Getachew Bisrat
SNNPR/ Lemo/Jawe and Upper-Gana	Fikadu Tessema

The assistant site coordinator took up their responsibilities in July / August. They will responsible for supporting the site coordinators in running our activities and liaising with partners at each of the Africa RISING sites. In addition they will provide logistical and facilitation support to ensure the smooth operation of our site-level innovation platforms (woreda, kebele and Farmer Research Groups).

Annexes: Research protocol summaries

Theme 1: Feed and Forage Development

T1-14-01 Participatory evaluation of techniques to improve the utilization of crop residues by farm households

In the mixed crop-livestock farming systems of Ethiopian highlands, crop residues (CR) constitute an important part of livestock diet, particularly in the dry period when green forage is scarce. In most cases CR are stored as heaps in the open air and feeding takes place by spreading a portion on the ground. These traditional management practices result in considerable loss of CR biomass and quality due to weather, pests, contamination and prolonged storage. The adoption of improved methods of storage and feeding practices will minimize wastage, improve the nutritive value could be a cost-effective feed resource to overcome feed shortage in the dry season. It is also hypothesized that farmers with better livestock market orientations can readily adopt improved CR utilization for increased livestock productivity. Participatory action research and laboratory testing is therefore required to document local practices and CR nutritive value and assess the impact of the adoption of improved techniques by farmers on:

- CR wastage and quality deterioration during the storage period
- The proportion of CR refusal during feeding
- The need for a supplementation plan for CR diets

If farmers adopt cost-effective techniques that improve the quality and utilization of CR, it will increase their farm/livestock productivity. Moreover, documenting the relationships between livestock market access/orientation of farmers and their CR management and readiness to adopt new techniques will provide valuable input for future technology interventions.
The expected outcome of this research is that farmers in the research sites will be acquainted with and adopt new technologies that minimize wastage of crop residues during storage and feeding, while at the same time improving the palatability and the feeding value of the residue. The techniques will help farmers to effectively utilize the available crop residue biomass and increase their farm productivity. During the evaluation process, forums will be created where farmers within and outside the group will share knowledge and experiences on how to further improve the handling and utilization of CR. This will in turn increase awareness among farmers, and enable to scale out better practices of CR utilizations identified in the participatory evaluation.

Activities Addressed and Delivery Date
2.1.1, 2.1.4 – June 30, 2015
CGIAR and Associated Partners
ILRI, ICARDA

T1-14-02 Pilot study on supplemental irrigated fodder production for fattening sheep at Lemo

Small scale irrigation practices are vital to the intensification of crop-livestock mixed farming system in the Ethiopian highlands. In the Lemo Africa RISING site a number of farmers have shallow wells and started to practice small scale irrigation to produce vegetables, using treadle and hip pumps distributed on loan through Africa RISING project. In Angacha district farmers have also previous experience in using rope & washer pumps for vegetable production. Integration of the small scale irrigation with livestock rearing through production of irrigated fodders and fattening practices may diversify and increase the income of farmers. Sheep fattening by supplementing locally available feeds with fast growing irrigated fodder plants (oat and vetch) may be a viable option for intensification, especially with farmers who have limited land space and cannot allocate large areas to grow fodder for large ruminants. Moreover, there are good fattening sheep types in the area

(Doyogana sheep) and the demand for fattened sheep is high during major holidays. This practice may also allow efficient conversion of locally available feed resources including unmarketable (low-grade) vegetables and crop residues into a high value product (meat) and increase the intake of crop residues which have poor intake rate when fed alone. A participatory action research exercise is therefore required to investigate the effect of this practice on the income of farmers and the trade-offs in the utilization of irrigation water for supplemental fodder production. Women tend to be less involved in fattening due to lack of feed and labour requirements. Therefore they sell younger sheep (yearling) and earn less unlike the men who bring bigger sheep to the market. Therefore this project has great potential to increase women's participation in fattening and benefit more from the sheep value chain through increased access to and control of fodder.

Income diversification and increased integration of crop-livestock systems is important to improve the livelihood of smallholder farmers. This pilot project will enable to explore the available opportunities for farmers with regard to sheep fattening using irrigated fodder as a supplement to crop residues and other locally available feeds. The project will enable to establish the feasibility of irrigated fodder production during the dry period to diversify the income of farmers and to further integrate mixed crop-livestock systems. Farmers will get opportunities to acquaint themselves with improved management of cultivated fodder of fattening sheep and share experiences on how to effectively utilize locally available feed resources. Major value chain actors and constraints for sheep fattening and marketing in the districts will be identified. The practice would contribute to increased access to and control of fodder by women and disadvantaged groups. The lessons learned from this pilot project will be used as valuable inputs to scale out irrigated fodder-fattening practices within and outside the Africa RISING sites.

Activities Addressed and Delivery Date
4.1.2 – June 30, 2015
CGIAR and Associated Partners
ILRI, IWMI

Theme 2: Field Crop Varietal Selection and Management

T2-14-01 - Addressing the yield gap challenge in the Ethiopian highlands through improved management practices

Matching crop-specific fertilizer regimes, including types and amounts, with local soil and seasonal climate conditions coupled with the use of improved crop varieties has the potential to greatly reduce the existing yield gaps in AR sites. While local resources such as crop residue and manure are used by many farmers, additional knowledge on their appropriate management including combination with external resources such as fertilizers is needed at the local level to increase their use efficiency. On-farm demonstration and experiential learning where farmer experiment on own field with 1 or 2 selected practices can result in widespread adoption and adaptation of technologies, under varied farmer management and local conditions. Thus by applying the principle that yield is a function of genotype, environment and management, we seek to move farmers from the current practice of low input use to a profitable use of improved seed, optimal fertilizer amounts, nutrients (organic and inorganic), while adapting the technologies to the varied local conditions. Applying this concept can significantly help address the yield gap observed on many smallholder farmers' fields, while at the same time, equipping farmers with needed skills to improve farming.

This work will provide information on the missing links in soil and crop management in AR sites (initially in two sites) in Ethiopia. It will demonstrate best management approaches for improved varieties in different configurations of rotations. Through this, a yield increase of at least 25% is expected among practising farmers. A catalogue of technologies that have potential for profitability under local conditions in each of the villages will be developed. The findings of the research will be presented at a community workshop for validation and dissemination. By linking with proposed soil fertility and alternative erosion management activities (3.1.1-3 and 4.1.1-2) under Theme 4 and results of work on varietal selection, technology packages that will be demonstrated stand a high chance of success. The work will also enhance the capacity of existing extension personnel who will continue to have impact on the villages beyond the project life.

Activities Addressed and Delivery Date
2.2.1, 2.2.2, 2.2.3, 2.3.1 – November 30, 2015
CGIAR and Associated Partners
ILRI, ICARDA

T2-14-02 Participatory variety selection of wheat, barley, faba bean and potato combined with double cropping of short duration crops

The Ethiopian highlands are characterized by cereal-food legume production system where the productivity is very low due to pests, poor agronomic practices and growing of unimproved cultivars. Potato is becoming an integral parts of the production system of the highlands. Sustainability of cereals (wheat and barley) and potato is maintained through regular rotation with food legumes in small and main rainy seasons of the highlands. During the implementation of AR in Bale highlands and other projects, it was possible to identify high yielding cereal, faba bean and potato cultivars that can provide high yield and contribute to food security. However, many varieties are not tested in all the four AR sites. Moreover, there are early maturing legumes that can be used in double cropping with cereal and potato to increase land productivity in the highlands. Most of the wheat, barley, potato and faba bean cultivars released are developed with little or involvements of farmers

and hence there is a need to put these varieties under PVS where farmers' inputs will be considered. Therefore, this study/intervention is designed to evaluate cultivars of the four commodities following PVS approaches as well as testing double cropping to increase land productivity.

A Participatory Variety Selection (PVS) trial, consisting of 3-5 released cultivars, each for food barley, malt barley, faba bean, potato and bread wheat will be conducted (all varieties of one crop /farmer and five farmers/site) in the four Africa RISING sites. Each cultivar of each crop will be planted on a minimum of 100m2 plot of land. Immediately after harvest, double cropping systems will be tested by superimposing short duration crops on the PVS treatments. For this, short duration varieties of chickpea, lentil, barley and possibly potato will relayed into / doubled-cropped after the PVS crops. The double cropping component will be implemented in Sinana, Lemu and Endemehoni sites (4 farmers/site). All field trials will be jointly managed by participating farmers, Researchers from Sinana, Debre Birhan, and Endemehoni and AR site coordinators. All agronomic, insect pests, diseases, yield and gender data will be collected and training of extension and farmers as well as field days will be organized. Participating farmers in this action search will be drawn from the IP-clusters established in each AR action kebeles. Selected cultivars will be further evaluated during the small rainy season and supplementary irrigation in North Shoa and Bale highlands in 2015.

Activities Addressed and Delivery Date
1.1.2 – June 30, 2015
CGIAR and Associated Partners
ICARDA, CIP, CIMMYT

T2-14-03 Stepwise intensification options for small-scale Faba Bean / forage production systems

The demonstration activities with faba beans undertaken at the Africa RISING research sites during the Meher season of 2013 highlighted the differences between farmers' existing practices and those required for the successful adoption of improved bean variety / management packages. Most significantly, we have observed farmers in SNNPR and Amhara regions weeding their bean crops very late leaving volunteer wild oats, other grass weeds and *Trifolium* sp. to create an *ad hoc* forage – bean intercrop. As a source of forage, these "weeds" are significant. A preliminary study conducted at Lemo has indicated that up to 2 tonnes (average: 1.4 tonnes) of wild oat forage dry matter may be made available within a growing season. Moreover, the establishment costs for the forage component are, effectively, zero making this a very cost effective source of what is actually quite high quality forage. This protocol proposes a systematic exploration of a set of possible intensification trajectories for the forage – bean intercrop. This needs to include the identification of (1) competition-tolerant bean varieties that can recover after the forage crop is removed under farmers' existing practice, (2) the possibility of identifying alternative forages to increase productivity whilst retaining the cost benefits of the volunteer-based forage crop and (3) options for stepwise intensification towards specialised bean production for those farmers who begin to appreciate the benefits of market participation.

This research will lead to a clear view of the relative benefits of a range of options for intensification of a sub-system that generates food, forage and cash income for farmers. These options will differ in the extent to which farmers need to make an initial commitment to intensification; from interventions that require minimal changes in management practices (other than a change of variety) and are, therefore, more likely to be adoptable in the short term to interventions that require significant change of practice but have the potential to generate a greater overall returns. Farmers participating in the research will provide an evidence base that the concept of flexible

intensification trajectories and including a robust trade off analysis will constitute sound basis for future scaling of the innovations within and beyond Africa RISING research sites.

Theme 3: Integration of High Value Products into Mixed Farming Systems

T3-14-01 Integration of high value multipurpose trees with soil and water conservation measures for improved livelihood and reducing land degradation

Most of the Ethiopian highlands have complex topography and are sensitive to different land degradation processes. The Africa RISING research sites are situated above 2100m asl where there is a high potential to grow high value crops including apple, pear, peach, olive, plum, avocado plant species for essential oils and other products. At present traditional annual crop- livestock farming systems are practiced in these fragile areas and annual crop yields are very low due to frost and poor soil fertility. Because of this and other associated reasons, most smallholder farmers in the AR sites are facing problems of food insecurity and under-nutrition, among others. Thus, introducing high value crops in the AR sites would contribute 1) to improve food security, feed, nutrition and health, 2) to diversify and increase source of income, 3) to mitigate the problems of soil erosion, nutrient depletion and degradation and 4) to convince farmers to manage their livestock better to protect their valuable crops from open grazing. However integrating multipurpose trees, particularly, temperate fruit trees, is relatively new in the AR sites in particular and in Ethiopia in general. According to the local knowledge studies carried out in AR sites, multipurpose trees integration into the mixed crop-livestock system was one of the farmers' priorities and government's interest. However, introducing multipurpose trees has some challenges including, but not limited to, 1) Inaccessibility and unavailability of quality germplasm at a required quantity, 2) lack of technical knowhow in propagation and management techniques (both NARS and farmers particularly in temperate fruit trees), 3) open grazing system, 4) lack of awareness and familiarity with the potential opportunities that high value trees can contribute, and 5) lack of water sources for irrigation. This intervention will respond to the local demand and government's initiative to introduce high value trees and campaign for their wider adoption.

Smallholder farmers in the sites have not benefited from multipurpose trees because of several reasons including those mentioned above. This intervention will raise farmers' knowhow and awareness on the benefits of integrating multipurpose high value trees to the mixed crop-livestock systems. The integration will improve farmers' productivity, income, nutrition, soil fertility and other products and services. Government extension, EIAR, regional research institutes, NGOs and CBOs will recognize the benefits derived from introduction of high value multipurpose trees and will mainstream to their development programs. Decision-makers will be better informed and recognize on women's role on fruit production and develop gender sensitive policy options. Wider adoption of fruits will be facilitated through an increased awareness by farmers and recognition by development partners (including the government, EIAR, NGOs, and CBOs). This will also lead to mainstreaming of high value trees to the national system and scaling-up through creating partnership and information sharing platform at different levels. Farmers will be convinced to implement controlled grazing system. Project sites, interventions and activities will be properly geo referenced and documented for future monitoring and evaluation. Partnerships, innovation platforms and publications will enhance awareness and encourage adoption. These will ultimately help design other projects as well as government initiatives to expand interventions to other regions.

Activities Addressed and Delivery Date
1.1.1, 1.1.2, 1.2.1, 1.2.2 – December 31, 2016
CGIAR and Associated Partners
ICRAF, IWMI, CIAT, ILRI, Private sector

T3-14-02 Cultivating women's' income and watershed resilience in market gardens

Communities in Ethiopian highlands are trapped in a vicious cycle of resources degradation, weak institutional capacity and lack of financial resources to overcome these challenges. The pressure on the natural resource base also poses challenges and often leads to increased conflicts between the various land uses and users across the landscape. Such conflicts often arise when some of the essential services or functions of the landscape are partially or entirely lost or when benefits are not shared appropriately. There are successful bright spots in Ethiopia, whereby few communities have undergone a substantial livelihood change by intensively managing small patches of land within the farm for growing market-oriented produces (market gardens) as well as testing and integrating food security crops, particularly Enset, Sweet Potato and Potato and highland fruits. A market garden is a business-oriented, relatively small patch of land within a farm or a landscape providing wide range and steady supply of fresh produces throughput the year. These gardens are commonly small plots around the house or watering points. Such areas generally receive 'preferential management' as they could be fertilised by household refuse, manure, crop residue and night soil, have higher soil organic matter, higher soil water holding capacity and support healthy and high yielding crops. Given the limited amount of inputs required, higher returns of per unit of labour and water investment, low risk of gardens in terms of theft and land tenure, market gardens could be used as an incentive to improve watershed management. They serve the nutritional requirements of children and women through a year round production of legumes, vegetables, fruits and greens. There is thus a possibility to enhance the food security and nutrition requirements of households especially women and children by re-organizing land use across landscapes. A more convincing evidence for developing this proposal emanated from a successful market garden development experience in a drought-prone region in Northern Ethiopia, Bati, which was severely affected by recurrent drought of the 1980s and heavily relied on food aid for about 20 years. Farmers adopted a combination of home garden interventions along with water harvesting and conservation agriculture. In ten years' time, they have moved from food aid to food security and in another 10 years they have increased their income from desperate poverty to an average household income of 5500 USD per year (http://www.raw.info/latest/when-water-is-scarce). The watershed has also changed towards an ecologically sustainable farming system.

The anticipated outcome of this study would be:

- Increased child nutrition, household income and resilience of resource-poor farmers,
- particularly women, through integration of market garden innovations;
- Improved market linkages of resource poor farmers using market gardens as entry points;
- Institutional and socio-economic incentives identified for development, management, expansion and adoption of market gardens;
- Investment costs of market gardens in various market scenarios established;
- Strategies for facilitating improvements in landscapes developed and disseminated;
- Evidence for policy makers and investors developed and widely shared;

Activities Addressed and Delivery Date
1.1.1, 1.1.3, 1.2.1, 1.2.3 – December 31, 2016
CGIAR and Associated Partners
ICRISAT, ICRAF, CIAT

Theme 4: Improved Land and Water Management for Sustainability.

T4-14-01 Mainstreaming of land/soil management practices that counteract soil fertility depletion

Surveys carried out by Africa RISING in 2013 revealed that inappropriate soil fertility management in the eight selected kebeles in general, and absence of rational use of mineral fertilizer in the Gudo Beret kebele (Amhara Region) and Jawe kebele (SNNPR Region) in particular, lead to soil mining and a loss of soil fertility. However, more in-depth information of major soil fertility constraints at sub-regional scale is missing. In addition, there is no adequate information on appropriate fertilizer recommendations that address issues of soil health while at the same time are acceptable by the farming community. Likewise, it is currently unknown what incentives would be required for smallholders to adopt sustainable land management practices, if such entail tradeoffs that currently provide disincentives for farmers to change business-as-usual practices. Computer simulation tools, such as crop-soil simulation models, provide options for fast and wide-scale assessment of soil fertility dynamics and impacts of organic and/or inorganic fertilizer management practices in a predictive fashion. They are ideal tools to carry out scenario (what-if) analyses under current and best-bet, sustainable intensification conditions. These can also be used in combination with other models (livestock production models, household consumption models), to analyze soil fertility – agricultural production – livelihood tradeoffs.

Projected outcomes include:

- National Ethiopian scientists will be in a better position to improve fertilizer management recommendations while accommodating soil fertility constraints, the sustainability of intensified crop production, as well as farmers socio-economic constraints
- Farmers in the selected kebeles consider soil fertility management in their planning
- Sustainably increased crop production
- Reduced vulnerability and production risk (risk of investment in inputs) of smallholders in the selected kebeles
- Informed decision making by local, regional, and national stakeholders will strengthen
- Communicating results in workshop will strengthen stakeholders buy-in
- Reports, training manuals and articles

Activities Addressed and Delivery Date
3.1.1, 3.1.2, 3.1.3 – July 31, 2015
CGIAR and Associated Partners
CIAT, ICRISAT, ATA, ICARDA, ICRAF

T4-14-02 Assessing the severity, spatial pattern and major drivers of soil erosion to recommend appropriate and sustainable land management options

Soil erosion is a serious problem in Ethiopia affecting food security, infrastructure and development activities. Various processes initiate and aggravate soil erosion including rainfall intensity, terrain, surface cover, land-use and management practices. Different endogenous and exogenous drivers such as population pressure, climate change, deforestation, overgrazing, land tenure, farmer's livelihood and coping strategies also dictate the severity and spatial dynamics of soil erosion. It is thus crucial to map the spatial variability of soil loss, understand the key drivers and identify the

major hotspot areas to plan for priority areas of intervention and corresponding sustainable land management (SLM) options. In this study, participatory and modeling approaches will be used to map the severity and spatial dynamics of soil erosion and identify appropriate land use and management options to tackle soil loss at representative kebeles of each Africa RISING Woreda. The potentials of mosaics of interventions across the landscape will be evaluated in order to understand synergies and trade-offs. As there is evidence that many implemented SLM and conservation measures have not succeeded as anticipated, policy, institutional and other socio-economic setups required for success will also be investigated.

The research will provide information on the severity and driving forces of soil erosion and identify hotspots that require priority management intervention. The modeling and simulation results will help identify site-specific and problem-oriented SLM and SWC options that reduce soil erosion risk and improve productivity. The participatory approach will equip farmers' understanding and perception of soil erosion and its drivers and thus increase their awareness and adoption of feasible and acceptable SLM and SWC technologies. Socio-economic and trade-off analysis results under theme 4.1 will also inform best-bet and acceptable technologies suited to arrest soil erosion. Local and regional stakeholders as well as other partners understand the severity and spatial dynamics of soil erosion and evaluate the significances of different of land-use and management options. Presentation of modeling outputs will help farmers and regional officers understand the benefits and trade-offs of site-specific and problem-oriented management options vis-à-vis stakeholder preferences. Community level partnership will allow implementation of identified SLM options targeting selected erosion hotspots. Based on the outputs of the research, provisional recommendations will be made on necessary policy and institutional setups for the proper implementation and effectiveness of SLM and SWC options. The whole approach used in the study will be documented and made available to guide up- and/or out-scaling to other sites. In 2015 and beyond, more elaborated in situ testing of the "promising approaches" identified in this study and suggested from other AR themes will be tested and demonstrated on selected hotspots.

Activities Addressed and Delivery Date
4.1.1, 4.1.2 – June 30, 2015
CGIAR and Associated Partners
CIAT, ICRISAT, ICARDA, ICRAF, Mekele University

T4-14-03 Enhancing food security and environmental stability through landscape based integrated water and land management

Rainfall variability, poor soil fertility and soil erosion are serious challenges of food security to rural communities in different parts of Ethiopia. With population pressure and climate change, the severity and impacts of these challenges will likely increase. Sustainable intensification at farm scale cannot be achieved unless land improvement measures are taken through sustainable water and land management. A number of natural resources management efforts have been implemented in Ethiopia since the 1970s. However, most of the introduced technologies were not based on combining scientific and traditional knowledge, and as a result performance was far below expectations. In addition, the top-down approach followed created less incentive and community participation. Recent evidences show that participatory landscape based integrated natural resources management is useful approach to reduce resources degradation and improve agricultural productivity. Considering that different potentials and constraints exist across the landscape continuum, it will be essential to design and implement targeted interventions geared to specific landscape and socio-economic conditions. In this study, community based participatory approach will form the basis for improving food security through targeted interventions such as soil/water conservation, afforestation, enclosures, agroforestry, water storage options (peculation systems,

check dams, ditches, etc.), water harvesting strategies (river diversion and borehole), horticulture and home-gardens across different landscape positions. Emphasis will be given to awareness creation, community mobilization, capacity building, partnerships and multidisciplinary approaches to enhance technology adoption and sustainable use. “AR Landscapes” will be created to demonstrate and implement integrated land and water management technologies in a participatory way. Hydrological model and community evaluation will be used to assess impacts of intervention and facilitate out-/up-scaling. This protocol will contribute to and benefits from various AR themes.

The implementation of this project is expected to have the following outcomes:

- Community awareness resulted in ownership and increased participation for implementation.
- Communities implemented sustainable afforestation, SWC and water harvesting measures.
- Soil moisture increased and soil erosion decreased as a result of integrated SWC efforts.
- New springs emerged and existing ones discharged more, harvested water provided irrigation.
- Livestock feed availability and soil health improved.
- Diversification such as fruits/vegetables and home-gardens improved nutritious food for household, especially for the youth and women.
- More resilient communities and landscapes to climate change and other external pressures
- Improved upslope-downslope community interaction to sustain conservation efforts.
- Integrated water and soil management model developed for extension officers, MoA and other partners for up scaling.
- AR and USAID will have effective, functional demonstration sites.
- Training manual and guidelines developed to aid up scaling and technology dissemination.

Activities Addressed and Delivery Date
1.1.1, 1.2.1, 1.2.2, 2.1.1, 2.1.2 – January 31, 2016
CGIAR and Associated Partners
CIAT, ICRISAT, IWMI, ICRAF, ILRI, Mekele University

T4-14-04 Testing of permanent raised bed systems for soil and water conservation and crop intensification

Multispecies copping systems (relay or double cropping systems) require more soil moisture the monocrops. While residual soil moisture in conventional cropping systems may suffice in years with average or above average rainfall, water may limit crop growth in years with years with below average rainfall – a situation that is likely to occur more frequently as the effects of climate change are getting more pronounced. It is therefore critically important to introduce technologies allowing farmers to maximize the availability of residual soil moisture.

Conservation agriculture (CA) is being widely advocated to conserve (soil and) water, while maintaining soil organic carbon and cut on production costs. However, the application of CA is challenging under the conditions typical to African smallholders for a number of reasons including competition for biomass with livestock and unavailability of specialized seeders and herbicide.
In this situation, the use of permanent raised beds shaped and reshaped annually by the local maresha ard plough – as developed on the vertisols of Northern Ethiopia by the University of Mekelle and CIMMYT – may represent an attractive option. Permanent raised bed allow for soil and water conservation with minimum surface mulch, as these structures increase soil rugosity and thus reduce runoff while increasing infiltration. In Northern Ethiopia, permanent raised bed resulted in a reduction of runoff by more than half, a reduction of soil losses through erosion by a factor more

than 4, significantly higher soil organic matter content in the ploughed layer, and improvement in crop yields, albeit only from the fifth season onward. Permanent raised bed also allows for shallow mechanical weed control in the furrows, thus minimizing the need for herbicide or manual labour. For small grain cops (e.g. wheat) the use of raised beds enables reduce seed rates without decreasing grain yield and reduce logging. Raised beds also improve field access (e.g. allowing N application at 1st node and boot stages, when crop N use efficiency is the highest).

We anticipate that permanent raised bed will increase soil moisture, allowing for the production of a relay pulse (chickpea, grasspea or lentil). Outcomes will include cropping recommendations to save on energy (particularly draught power) and increase water-use efficiency, perception by farmers of such alternative cropping practices, and cost/benefit analysis.

Activities Addressed and Delivery Date
4.1.1, 4.1.2 – September 30, 2015
CGIAR and Associated Partners
CIMMYT, CIP, ICARDA

T4-14-05 Relay cropping of high value crops through supplementary furrow irrigation using mounted motorized pumps

Irrigated agriculture has been on the rise in recent years in the rainfed agricultural systems of Ethiopia both as a livelihood diversification and a climate change adaptation strategy. Abstracting, conveying and applying irrigation water is an important component of the total production cost in irrigated agriculture and affects the profitability of the irrigation technology and thus the economic incentives to farmers. Motorized pumps mounted on and powered by small multifunctional two-wheel tractors can be used to abstract and convey water to farm irrigation sites. As these tractors can also be used for land preparation, post-harvest operations and transport, we hypothesize that this type of mechanized irrigation is more adoptable for smallholders than mechanized irrigation using pumps powered by their own engine. On the irrigation site, irrigated water can be applied through furrows between raised planting beds, which is more efficient than flood irrigation on a flat surface. Raised bed can be shaped using a simple tool-bar based furrower pulled by the same tractor used to power the motorized pump. Raised bed also brings a number of benefits such as reduced seed rates and increased access to the field for weeding and fertilizer application.

Presumably, productivity and profitability can be increased as a result of supplementary irrigation. However, the profitability of mounted motorized pumps in relation to the capital and operational cost of the technology is unknown for the Ethiopian Highlands. This protocol proposes to fill this knowledge gap. It links directly with 2 other Africa RISING protocols:

- The CIMMYT-led 'Testing of permanent raised bed systems for soil and water conservation and crop intensification'
- The CIMMYT-led 'Giving power to Africa RISING farmers through small mechanization'

The work will deliver information to local communities, extension agents and policy makers on how to improve the profitability of mounted motorized pumps to contribute towards sustainable intensification. In addition to the selected sites an ex-ante assessment of instruments can improve cost effectiveness and profitability of the technology?

Activities Addressed and Delivery Date
2.1.1, 2.1.2 – June 15, 2015
CGIAR and Associated Partners
IWMI, CIMMYT

T4-14-06 Bridging yield gaps through soil test-based nutrient amendments

There is an increasing evidence that crop yield is not increasing in Ethiopia despite huge investments in soil and water conservation, import of chemical fertilizers, increasing investment in small scale irrigation and expanding efforts of the extension system to reach every household in the country. More over pests and diseases are becoming major threats of production, particularly for high value produces. Opening up new land replacing wetlands, forests and hills mostly satisfies the increasing food demand. Although land degradation and nutrient mining is a widely recognized production constraint, crops are rarely responding to the application of the conventional macronutrients, even in soils where application of chemical fertilizers is a first time experience. As a result, the objective of the Ethiopian government to increase yield per unit of land and labour and to improve food security remained to be a challenge. There is unproven local perception that crops in the Ethiopian soils are not responding to the application of fertilizer mainly macronutrients. As a result the Government of Ethiopia, the sole importer of farm inputs, has been importing only Nitrogen and Phosphorus fertilizers to the country. On the other hand, lack of response to Nitrogen and Phosphorus fertilizers could be largely due to the critical deficiencies of multiple micro and secondary nutrients, which are holding back the potential of rainfed and irrigated agriculture. When micro-nutrients become a limiting factor water, fertilizer and other high-energy production inputs may be wasted, since a plant will only grow and develop to the extent that its most limiting growth factor will allow (Mengel, 2012). Many times the hidden hunger for micro and secondary nutrients is not visible, however, such deficiencies make plants vulnerable to attacks by pathogens and insect pests and also the symptoms are considered as disease symptoms. ICRISAT's participatory research for development approach using watershed and soil test-based nutrient management as an entry point activity in Bhoochetana, the state of Karnataka, India (ICRISAT, 2013) have shown that rainfed crops respond very well to application of deficient micro nutrients (zinc, boron and sulphur) and increased crop yields by 20 to 66% on 3.7 million hectares, with an economic impact of around US$ 130 million. The economic returns of Bhoochetana revealed that benefit cost ratio for the farmers were 2.1 to 15:1 with full costing of the inputs added by the farmers (ICRISAT, 2013). Based on the evidence of strategic research undertaken by ICRISAT-led consortium in India and other countries in Asia we proposed to assess nutrient deficiencies and test particularly with reference to micro and secondary nutrients in Ethiopia and develop a scaling-up model in two districts of different agroecologies to achieve the impact in terms of increased agricultural production and improved livelihoods with sustainable intensification.

Key outcomes include:

- First-hand information of critical deficiencies of micro and secondary nutrients in the region which could be holding back the potential will be available.
- Soil health status maps for the selected region will be available to share the information with different stakeholders and enhance the awareness amongst the policy makers, development workers, researchers and farmers for increasing agricultural productivity
- A 'proof of concept' of scalable participatory research for development using knowledge-based entry point activity will be available for application in the region.
- Policy influence on the quality and type of import of fertilizers to Ethiopia
- Increased productivity of crops through enhanced nutrient and water use efficiency to benefit the farmers.

Activities Addressed and Delivery Date
3.1.1, 3.1.3, 4.1.1 – December 15, 2014
CGIAR and Associated Partners
ICRISAT, CIAT, ATA

Theme 5: Improving the Efficiency of Mixed Farming Systems through more Effective Crop - Livestock Integration

T5-14-01 Integrating tree lucerne in the crop-livestock farming systems of the Ethiopian highlands for multiple products and services

Feed shortage, soil fertility depletion, lack of wood for various products and low income for smallholder farmers are, among others, critical challenges in the Africa RISING (AR) research sites of the Ethiopian highlands (PCA report, 2013). Identification of different options that enhance crop and livestock productivity as well as diversify income sources are priorities for Africa RISING project. Integration of multipurpose trees such as tree lucerne (*Chamaecytisus palmensis*) in the crop-livestock farming system can be one potential option to support fodder availability, improve soil fertility and enhance crop-livestock productivity. Tree lucerne is a nitrogen fixing species (100 kg N ha^{-1}) and adaptable for use in highland areas (2000-3000 masl). It has potential for use as livestock fodder (leaves with 20-30 % protein and 77-82 % IVDMD), fencing and housing as a component of livestock value chains. The plant also has potential for use as fertiliser, biological soil conservation, wind break and fencing as a component of crop value chains. Some farmers in AR sites such as Basona *kebele* have already started selling tree lucerne seeds to generate additional income. However, women have limited access to fodder which constrains investment in livestock as well as sustainable agricultural intensification. The integration of tree lucerne to the crop-livestock farming system could save labour and time spent to look for fodder and fuel. The intervention could be an incentive to women and marginalized groups to invest in mixed farming systems.

Research, extension and none governmental organizations have been trying to promote planting of multipurpose trees like tree lucerne in the highlands of Ethiopia. However, the success has not been as expected due to lack of approaches that consider farmers needs and realities. The participatory and targeted research approach and the training and experience sharing schemes from the current project will enable farmers to grow more tree lucerne plants and improve the availability of biomass for supplementary feed, soil fertility improvement and other products and services. The synthesis that we intend to write from the research approach can serve as a guide for the extension to promote growing of more multipurpose trees, covering more areas within and beyond the Africa RISING research sites and benefits more farmers. We expect increased women's access to and control of fodder and biomass, and labour saving. Feed and forage combinations that are appropriate for men and women in different agro-ecological zones will also be available. Gender analysis will help us understand the areas to focus on so as to integrate men and women's issue, directly address them and also gauge who will benefit and how gender relations within the household will change.

Activities Addressed and Delivery Date
3.1.1, 3.1.2, 3.1.3 – December 31, 2016
CGIAR and Associated Partners
ILRI, ICRAF, ICARDA, CIP

T5-14-02 Facilitating change in cropping systems to improve nutrition, income and food security

Food shortage in Ethiopia is predominantly taken as a function of limited access to food in terms of quantity, but it has been rarely treated as a function of non-balanced nutrition. The current grain-based cropping system lacks real incentives for diversification of crops and nutrition-oriented innovative farming. Malnutrition of the vulnerable groups (children and women) could occur even in good crop harvest years and in regions of high potential because of non-balanced food intake and lack of diversity. Studies showed that about 45% of the children in Ethiopia are stunted and about 42% are underweight, associated with zinc, iron and Vit.A deficiency (www.bioline.org.br/request?nd09041). Rural households rarely consume animal products as they are scarce sources of cash. Dietary supplements are also rarely available to the rural poor. Therefore, there is a need to establish the level of hidden hunger in the farming systems of Africa RISING districts across social categories and develop a strategy that would improve household nutrition with the existing land and water resources. One possible option to reverse the risk of malnutrition and low farm income is modifying the production system by reallocating cropland in favor of crops with high content of nutrients in deficit and high financial returns. Analyzing households' production of nutrients on farm across farming systems could be valuable in guiding intensification of those systems both in market-oriented and subsistence sub-systems (Amede and Delve, 2008) and to guide research and development investments. Participatory modeling tools would help to evaluate household level food security and cash income, and to assess trade-offs in water, nutrient and labour use while modifying the respective farming systems to achieve the intended production objectives. It will also help to identify farm and landscapes niches where interventions could be integrated across rainfall gradients, market opportunities, gender categories and wealth groups. The tool would also be used to establish whether communities in the various farming systems are currently above or below poverty line (1.25 USD per day) with the existing production practices and create production scenarios that could lift these communities out of vicious poverty cycle.

The anticipated outcome of this study would be:

- Improved household nutrition of communities through altering cropping systems
- Policy awareness on the link between farming systems and hidden hunger (nutrient insecurity) in Ethiopia at household, community and higher scales;
- Guideline for development actors to target best-bet crop commodities with higher nutrient density to farming systems in deficit, without radically changing the food habit, market preferences and farmers' choices;
- Improved local capacity in participatory modeling for improved resource use and food security

Activities Addressed and Delivery Date
1.2.2, 2.1.4, 3.1.1 – December 15, 2014
CGIAR and Associated Partners
ICRISAT, CIAT, EPHI

Theme 6: Cross Cutting Problems and Opportunities.

T6-14-01 Creating linkages between farmer agribusinesses with key buyers for potato in the Africa RISING Ethiopia project

Lack of structured markets is major challenge for many farmers and traders caused by lack of organizing production and marketing institutions. Many farmers suffer from the problem of small quantities that usually is unattractive to many traders or buyers. This is due to high transaction costs and information problems, which present challenges in coordination of supply chains often leading to use of inappropriate varieties, underinvestment in storage and handling facilities, undersupply of finance and large intra- and inter-seasonal price fluctuations which undermine market participation and competitiveness. These are some of the challenges identified in the recent value chain studies by the project in the project sites. One way of structuring the market is through ensuring that producer institutions are well organized for collective marketing and that the producers are also able to access identifiable high value markets. This reduces costs of transacting between farmers and marketers. Building linkages for ware potatoes by improving the capacity of existing agribusinesses (cooperatives and other farmer based institutions and groups) to better link to end markets for ware potatoes (large traders and processors). A focus on the complete value chain will ensure that other interventions at the farm level (such as water harvesting) support the market interventions. More important is that as farmers increase their production, they have defined markets for their ware potato. The absence of an appropriate platform to facilitate these trading interactions reduces returns from farmers' farm operations. Low production and unreliable supplies and failure to meet desired quality and food safety standards for different markets, undermine development of competitive and equitable potato value chains.

Key outcomes include:

- Market linkages between producers and buyers strengthened
- Reduced transaction costs due to agribusinesses collectively market their produce
- Better profit margins and incomes from their products through strengthened bargaining and post-harvest handling for better quality
- Increased demand for and utilization of market support services
- Business models that support sustainable market linkages promoted

Activities Addressed and Delivery Date
3.1.2 – December 31, 2015
CGIAR and Associated Partners
CIAT, ILRI, CIP

T6-14-02 Facilitating establishment of potato seed businesses in the Africa RISING Ethiopia project

Reliable supply of quality seed is necessary to sustain high productivity among the farming communities. However, in many places, seeds of self-propagating and self-pollinating crops may fail to provide adequate incentives for private sector to invest in their supply. Thus seeds and planting materials that are released from the research process fail to reach the intended users due to lack of sustainable seed supply systems. The private sector feels that the returns on such investments are not assured. One of the challenges facing potato as an upcoming commodity enterprise is lack of consistent supply of planting materials, as shown by the recent value chain study in the project sites. The current system relies heavily on the public sector; however, a focus on seed supply as a business enterprise would link better the public sector (foundation seed) with the production of ware potato.

A sustainable seed enterprise should be able to contribute increased potato production and consequently food incomes of households.
Key outcomes include:

- Quantity of seeds of user demanded varieties increased
- Profitability of seed businesses improved
- Increase access by farmers to seeds of demanded crop varieties
- Entrepreneurial capacity of farmer agribusinesses to produce quality seeds enhanced
- Linkages between seed businesses and producers and seed traders improved

Activities Addressed and Delivery Date
1.2.1 – September 30, 2015
CGIAR and Associated Partners
CIAT, ILRI, CIP

T6-14-03 Decentralized system for community-based seed production and extension provision

Unavailability of quality seed of commonly grown crops was identified as one of the priority constraints to increased agricultural productivity in the four Africa RISING sites (PCA, 2013). The effectiveness of the national extension system is still low due to problems such as high turnover of staff which renders training efforts largely ineffective, poorly motivated extension staff and limited technical know-how of the frontline staff.

It is the aim of this activity to develop a system whereby these two constraints can be addressed simultaneously and in a sustainable manner, as far as possible relying on private initiative and community interest rather than being dependent on extension / input support provided by BoAs line agencies and/or NGOs. The approach will build on the Model Farmer (MF) concept and to combine it with a Farmer Field School (light) approach that promotes farmer-to-farmer extension. The MF concept is widely promoted by the GoE as a complementary, informal extension system aiming at bridging the existing 'last-meter gap' between the research system and farmers.

Based on the experiences made during the pilot phase (Belg season 2014) in 2 sites with the production of potato seed, the approach will be expanded to 4 AR sites, adding wheat and a legume (e.g. faba bean). In addition, to reduce post-harvest losses and to maintain seed quality, improved seed storage facilities for seed potatoes and grains will be introduced and tested.

The outcome of this study is an approach for decentralised seed production and extension service provision, increasing the local availability of good quality seed, addressing national key constraints for increased agricultural productivity. Information on farmer-acceptable, improved seed storage techniques will be generated. In collaboration with other centers (CIMMYT, ICARDA) templates for local seed supply systems are produced and seed supply systems for key Africa RISING crops (wheat, faba bean, potato) are established via Innovation Platforms and other partners. Experiences of the activity are documented and constraints identified as well as opportunities for wider scaling.

Activities Addressed and Delivery Date
1.1.2, 1.2.1, 1.2.2, 3.1.3 – June 30, 2016
CGIAR and Associated Partners
CIP, ICARDA, CIMMYT

T6-14-04 Giving power to Africa RISING farmers through small mechanization

Sustainable intensification (through the use of improved germplasms and/or relay / double cropping) will require more power, e.g. to handle the extra harvest and/or transport it to the market. Moreover, as identified during previous diagnostics, availability of farm labour is a serious constraint in CLP systems. A consequence of low farm mechanization is high labour drudgery, which affects women disproportionally (in, e.g. weeding, threshing, shelling and transport by head-loading). Moreover, labour drudgery makes farming unattractive for the youth.

This calls for the participatory testing of labour saving devices such as seeders, threshers, forage choppers and trailers. These could be powered by small, cheap, multipurpose and easy to maintain tractors such as single-axle two-wheel tractors (2WT).

Although these tractors are not powerful enough to plough, they can be used for seeding, either in a ploughed field or in an unploughed field (i.e. conservation agriculture).

Several seeders are commercially available from China and other countries. Moreover, CIMMYT and its partners recently produced a mobile multi-crop sheller/thresher for 2WT that can be converted into a trailer. We are proposing to participatory test this equipment in one pilot site of AfricaRISING sites.

Outcomes will include a better understanding of the demand for mechanization, suggestions by farmers and manufacturers to improve equipment being tested and simple cost/benefit analysis of the technologies tested.

Activities Addressed and Delivery Date
3.1.3 – July 31, 2015
CGIAR and Associated Partners
CIMMYT, CIP, ICARDA

T6-14-05 Pilot a system for decentralized, community-based seed potato production system, combined with a Farmer-to-Farmer extension service provision through Model or Lead Farmers and Farmer Field Schools

Unavailability of quality seed of commonly grown crops was one of the priority constraints to increased agricultural productivity identified during the PCA. It is the aim of this activity to develop a system whereby this bottleneck can be addressed in a sustainable manner, as far as possible relying on private initiative and community interest rather than be dependent on extension / input support provided by BoAs line agencies and/or NGOs. The approach will work closely with the Model/Lead Farmer concept (1 to 5) which is widely promoted by the GoE with a Farmer Field School (light) approach that promotes farmer-to-farmer extension.

The anticipated outcome of this study is that decentralised seed systems are being piloted and documented at kebele level, increasing the local availability of good quality seed potato. In collaboration with other centers (CIMMYT, ICARDA) design templates for seed supply systems are produced and pilot seed supply systems for key Africa RISING crops (wheat, faba bean, pea) established via Innovation Platform and other partners. Experiences of the pilots are documented and constraints identified as well as opportunities for wider scaling. Information will be collected regarding farmer perception of this decentralized seed production system and a participatory cost-benefit analysis will be carried out.

Activities Addressed and Delivery Date
1.1.2, 1.2.1, 1.2.2 – June 30, 2014
CGIAR and Associated Partners
CIP

T6-14-06 Promotion of diffused light storage for potato

Storage losses including impaired quality are partly caused by harvested crops not being stored in a product specific manner. Diffused Light Storage (DLS) is a post-harvest technology which uses natural indirect light instead of low temperature to control excessive sprout growth of potato seeds, extend their storage life, **reduce the associated storage losses** and improve productivity of the potato crop**.** It is a low cost method which provides a new opportunity for farmers to preserve the quality of seed potato. Quality Declared Planting Material (QDPM) is a value added product and must be stored in DLS.

The anticipated outcome of this study is that seed specific storage technologies are adopted within decentralised seed systems established on kebele level, increasing the overall quality of seed produced locally by farmers. Attention must be paid to specific major threats to products that are currently stored by farmers (rodents, tuber moth, theft). Via the IPs the potential for wider adoption of post-harvest technology will be established. Farmer feedback will be collected via key informant interviews to determine farmers' perception of this technology and potential bottlenecks for wider adoption.

Activities Addressed and Delivery Date
3.1.1 – April 30, 2014
CGIAR and Associated Partners
CIP

T6-14-07 Promotion of quality seed for potatoes

Quality seed is more expensive than ordinary seed. While farmers in most communities demand access to quality seed, few farmers are actually willing to pay the premium associated with seed of better quality. It is therefore necessary to promote the merits of quality seed so as to create a farmer-based demand and market for quality seed.

Data will be collected to answer the following research question: Does quality seed increase yield and income convincingly for farmers to pay higher prices for better seed? The results will be documented and constraints and opportunities for wider scaling identified to improve supply systems via Innovation Platform.

Activities Addressed and Delivery Date
1.2.1, 1.2.2 – May 31, 2014
CGIAR and Associated Partners
CIP

T6-14-08 Economic impact of market facilities in Central and Northern Highlands of Ethiopia

Lack of market infrastructure significantly undermines the market margins farmers generate from their agricultural products and elevate the prices they pay for agricultural products when involved as buyers. The transaction costs of agricultural markets in general are quite high due to, among others,

poorly structured and irregular supply, short shelf life of products, lack of transport facilities that force marketers to trek their animals, lack of feed and watering services in and around the markets, lack of veterinary services around markets, lack of storage facilities, and lack of market information. High transaction costs and information problems present challenges in coordination of supply chains which often lead to underinvestment in storage and handling facilities, undersupply of finance and large intra- and inter-seasonal price fluctuations which undermine market participation and competitiveness. Low production and unreliable supplies and failure to meet desired quality and food safety standards for alternative uses (food, feed and other), undermine development of competitive and equitable value chains. It is therefore imperative to emphasise the need for understanding the potential impact of delivery of key market facilities on the marketing performance of smallholder farmers. This study will employ state-of-the art scientific procedures to quantify the added monetary advantage smallholder farmers are going to get from accessing key market facilities in selected markets of the central highlands of Ethiopia.

The identification of key challenges market actors are facing and development of alternative institutional innovations will certainly bring about significant behavioral change both among consumers and traders in the agricultural markets. Informed smallholder marketers would make smart marketing decisions and hence would generate higher market margins. This will happen among other essentially through reduced transaction costs. This in itself will increase the efficiency of the markets such that markets will play indispensable role in increasing the speed and efficiency of resource allocation. Concomitantly, smallholders' livelihoods will improve as a result of improved market performance both as sellers and buyers. The findings will also help in increasing the relevance and effectiveness of agricultural market extension programs and interventions. This will be made possible as this study will chart the information on existing markets and underutilized values chain opportunities for smallholders to raise their incomes through reduced transaction costs and hence better prices for their produces.

Activities Addressed and Delivery Date
3.1.2 – February 15, 2016
CGIAR and Associated Partners
ICARDA, ILRI

T6-14-09 Building capacity of researchers and stakeholders to collect, analyse and interpret sex/gender-disaggregated data and understanding of the local culture

To get a deeper understanding of the local context surrounding mixed farming systems, intensification, gender gaps, norms and agency, it is important to have trained researchers and local personnel who are able to collect, analyse and interpret sex/gender-disaggregated data and understand the local culture and sensitivity of the topic. Researchers need to understand the local context and cultural values that govern gender relations at household and community level since they influence men and women's capacity to invest in economically productive activities. Therefore, there is need to enhance the capacity of implementing partners and local staff to collect sex/gender disaggregated data, conduct a gender analysis and use of the data to address gender-based constraints in agriculture. It is also important that partners are exposed to gendered approaches in analysing agricultural value chains. This will lead to better design of interventions and technologies that directly respond to the needs of men and women.

Stakeholders will be exposed to gender concepts and different tools to collect gender disaggregated data. Participants will be able to collect, analyse and interpret sex/gender-disaggregated data and

understand the local culture and sensitivity of the topic. As a result of the training workshops, there will be increased frequency and quality of gender integration efforts across Africa RISING sites.

Activities Addressed and Delivery Date
5.1.1, 5.1.2 – January 31, 2015
CGIAR and Associated Partners
ILRI, IWMI, IITA, ATA

T6-14-10 Diagnosis and characterization of the most important constraints that hinder women and marginalized groups from achieving full productivity potential and income generation

The status and role of men and women in all aspects of mixed farming systems differ markedly across agro-ecological areas and Africa RISING' action sites. A systematic literature review will provide a basis for understanding the key constraints that prevent women and other marginalized groups from investing in intensification and actively participate in project activities (including technology development, information sharing, meetings and trainings among others). This will provide a basis for testing and evaluating different approaches for increasing women's participation in and benefit from research for development interventions.

Gender-related constraints to intensification will be established which will be used to prioritize interventions and target appropriate technology clients. Research planning and implementation will incorporate information on constraints, needs and opportunities for gender-responsive innovation. Identification of social, economic and cultural barriers that prevent women and other marginalized groups from actively participating in various project activities. Structures and approaches that facilitate intensification, equal participation of men and women and more equitable benefit sharing will be established using gendered constrains and opportunities.

Activities Addressed and Delivery Date
4.1.1, 4.1.2 – December 31, 2015
CGIAR and Associated Partners
ILRI, IWMI, EIAR, ATA

Theme 7: Knowledge Management, Exchange and Capacity Development

T7-14-01 Integration of Africa RISING activities into a coherent project program

In 2013, participatory community analyses (PCA) were undertaken by multi-disciplinary facilitation teams in 8 *kebeles* in the Amhara, Tigray, Oromia and SNNPR regions, producing a list of priority farming enterprises, their current bottlenecks, as well as farmer-perceived opportunities for improving income, food security and/or reducing overall risks by intensifying farm enterprises. The PCA was carried out in discussions with kebele members and local leaders, with over 250 men, women and young people. Feedback on the results will be given to the farmers and future participatory planning and implementation of activities based on the results of the PCA and feedback sessions.

Contribute to the analysis of strengths, weaknesses and applicability of the methods used both alone and in combination. Contribute to the study of the adoption processes and common features of technologies and management practices currently used by farmers. Analyse synergies between contributing partners and programs.

Activities Addressed and Delivery Date
1.1.1, 1.1.2, 2.1.1, 3.1.3 – July 31, 2015
CGIAR and Associated Partners
CIP, ILRI

T7-14-02 Adoption and impact of improved food legumes in Bale Highlands: Intra and inter-household empirical analysis

Understanding the drivers of adoption and understanding the structure of the diffusion process are essential components of any research aimed at abating the challenges faced by resource poor households. So much has been done in developing improved varieties of food legumes (faba bean, field pea, lentil and chickpea) and in disseminating them in different parts of Ethiopia. Bale highlands are inhabited by resource poor farming communities depending enormously on legumes for nutrition, rotation in their cereal crops and animal feed. The decision to adopt a given technology is possible only if the utility (welfare benefit) derived from doing so is higher than not adopting. The willingness to adopt therefore varies depending on the level of perceived utility. This perception again varies across households and among different members within a household. Accordingly, the impact of the use of the adopted technologies varies depending on the characteristics of the users and the extent to which the technologies are used. This research aims at studying the driving forces behind the willingness to adopt (use or not in Belg and Meher seasons) and the intensity of adoption of improved legume cultivars considering differences among households – in terms of resource endowment, and differences within households (in terms of age and gender). The welfare impacts due to technology use will also be disaggregated based on resource endowments and gender differentials.

This research will identify the key driving forces – challenges and opportunities – that determine the willingness to use and the intensity of use of improved food legume technologies in Bale highlands. It would also empirically and comprehensively quantify the welfare impacts of the improved food legume technologies across households of different resource endowments and within households considering gender differences. The information to be generated will be communicated with the

study communities and key stakeholders in agricultural extension and development in the area. The communication will be designed in such a way that the communities and stakeholders will be able to use the findings in fine tuning their decision making procedures for better efficiency and effectiveness. Extension workers and decision makers at different levels will be able to design suitable approaches that can facilitate the adoptability of technologies and the adoption 'capacity' of farming households. The research procedure to be followed will also be meticulously documented and will be available for Africa RISING partners and other research and development institutions.

Activities Addressed and Delivery Date
2.1.1 – September 30, 2015
CGIAR and Associated Partners
ICARDA, CIAT

T7-14-03 Analysis of existing technologies and management practices addressing sustainable intensification of the farming system in the Ethiopian Highlands

Some technologies applied by farmers arise through tradition and local knowledge, some are introduced through government or NGO led interventions and some filter down through media access. An investigation is required to explore:

- The means by which they were disseminated into the community
- The reasons why farmers chose to adopt them
- Their limitations
- Barriers to further adoption
- The enabling processes (based on a range of social, biophysical, economic and political factors) that we might be able to make use of to increase the adoptability of Africa RISING innovations.

If trends can be discovered and contextual variation in drivers of adoption can be understood the research may then be used for identifying enabling pathways for adoption of new technologies.

Activities Addressed and Delivery Date
2.1.1 – October 31, 2014
CGIAR and Associated Partners
ILRI, ICRAF

T7-14-04 A three dimensional assessment of the perceptions of sustainability, and their role in the success of project interventions

Innovations usually bring with it some degree of benefit to its potential adopters but it equally creates some kind of uncertainties in the mind of adopters. This uncertainty is however reduced by the information embodied in the innovation itself in the form of the possible abilities of the Innovation to solve individual's perceived problems. The goal of the Africa RISING project is to introduce multiple interventions to achieve Sustainable intensification. This particular innovation has advantages as well as some challenges which need to be carefully examined to ensure that it benefits the poor farmers. The question to be addressed then is whether our interventions have the ability to solve Ethiopian farmers' perceived problems and alleviate poverty. For the project to be sustainable, it is equally important to consider the knowledge and perception of the farmers who are the potential adopters of our interventions. Farmers' perception and knowledge is crucial for successful research and development strategies. They further stated that many promising

agriculture policies have failed because they were inappropriate to farmer's needs and perception. Perception generally refers to how people select, organize and interpret information gained through the senses or experience. Sustainability of agricultural production is largely dependent on the action of farmers and their decision making abilities given the level of knowledge and information that is available to them. However, the role of perception has received very limited attention in studies regarding farmers' adoption of a new technology. Also, there has been a general failure of programs to address situations where farmers' knowledge is lacking and inadequate. Thus to prevent failure in our interventions through the Africa RISING Project and ensure sustainable intensification, a good understanding of the knowledge, needs and perception of the farmers is required in order to devise a systems approach of introducing the crop to them. Thus this study will focus on understanding the perception of farmers on issues of Sustainability with regards to their livelihoods and its coherence with research team members, as well as project definition of sustainability.

The study will bring out concrete understanding of role of perception of farmers in adoption of an intervention. They Study will also compare and contrast the coherence between the perception or definition of sustainability and its role in success of an intervention in creating Sustainable intensification. The study findings will be applied in future interventions by dealing with constraints to tech adoption.

Activities Addressed and Delivery Date
2.1.2 – June 30, 2015
CGIAR and Associated Partners
IWMI, ICRAF

T7-14-05 Design and pilot processes to enhance facilitation, communication and coordination of innovation platforms

Innovation platforms have been established as a primary mechanism for realising the Africa RISING research for development approach. Innovation platforms have already been established in all four Africa RISING sites, however, there is some confusion regarding how these platforms will operate in practice. There is therefore a need for clear and practical guidelines which can be used to ensure a common understanding of the platform process among the various stakeholders and clear steps for platform establishment and on-going communication and coordination. In order for these guidelines to be successful they will need to be supported by good facilitation. Previous research has highlighted the importance of facilitation skills but there are limited practical recommendations for how to develop the facilitation skills of platform members (particularly at the local level). This research activity will design and pilot facilitation training events, and develop training guidelines. These processes will be piloted to test their effectiveness and impact on IP members' capacity to innovate. This research activity will contribute to scaling up platform processes to innovate and ensuring their longer-term sustainability.

This research activity will produce easy to use, practical guidelines for facilitating and coordinating IPs that can be used in other sites, and can be updated/amended based on information generated by the on-going research activities. This research will also build capacity of partners in the four sites to facilitate IPs, and through this gain a more detailed understanding of what support local partners need in order to sustain such processes in the longer term. The outcomes of this research will contribute to developing piloted and replicable processes for IP establishment in other sites and projects.

Activities Addressed and Delivery Date
5.1.1, 5.1.2 – July 31, 2015

CGIAR and Associated Partners
ILRI, ICRAF, CIP

T7-14-06 Design and pilot processes and tools for monitoring and evaluating the impact of innovation platforms

Innovation platforms are an increasingly used in research for development projects. The aim of IPs is to bring together a range of stakeholders to identify and take action to address common problems. By identifying their own issues and designing their own solutions stakeholders are more likely to take ownership and make changes than if solutions are externally driven. However, despite the potential of innovation platforms, it can be hard to demonstrate their impact. Attributing impact can be difficult because often the problems that innovation platforms attempt to solve are complex , results may be hard to measure, and benefits may be unforeseen or take time to develop. There is a recognised need to develop participatory, accessible and user-friendly tools that can be used to better monitor and evaluate the impact of IPs. M&E processes can also be an important way of encouraging an iterative process of action, reflection and learning which is key for platforms to operate effectively. This research initiative will aim to design and pilot tools and processes for monitoring and evaluating platforms in the four Africa RISING sites. The results will be documented and analysed over the course of the Africa RISING project in order to enhance understanding of the impact of innovation platforms.

The anticipated outcome of this study is a training manual and piloted process for monitoring and evaluating local innovation platforms. Enhanced capacity of local partners to manage, monitor and evaluate innovation platform process and results is another anticipated outcome. This research will also produce data which can be used to assess the impact of innovation platforms processes, and potential weaknesses/challenges. The research findings will potentially be applicable to other research processes using innovation platforms, both in terms of the processes that are designed and the results that are generated.

Activities Addressed and Delivery Date
1.1.2 – July 31, 2015
CGIAR and Associated Partners
ILRI, IFPRI